INDEXED

International Marine Engineering

MARCH, 1907.

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THE TRIAL OF THE BATTLESHIP VERMONT.

In the teeth of a winter gale, the new battleship *Vermont* went through three trial trips for speed and endurance, and came out with splendid results. The first trial included fourteen runs alternately with and against the tide, for standardization of the propellers. This trial occurred on December 5, 1906, and showed that for the contract speed of 18 knots an average of 114.6 revolutions was required. The full power trial, December 7, lasted four hours, the average speed being 18.33 knots, as figured from an average of 117.12 revolutions per minute. The twenty-four hour endurance run, December 7 and 8, developed an average speed of 17.43 knots, with approximately 14,500 horsepower and 110.34 revolutions. The contract called for 13,200 horsepower, without limitation as to speed. This run was made under the most adverse conditions of extreme cold, heavy gale and a thick snow storm. We are informed by the builders, who furnished us with the illustrations of ice upon the decks at the conclusion of the trial, that the temperature in the fire rooms varied from 16 to 31 degrees Fahrenheit, and that drinking water set close to the furnaces was repeatedly frozen.

With the wind blowing at forty miles an hour, and the thermometer standing 12 degrees below zero, the ship was driven at high speed through a night so black that it was impossible to see anything more than twenty feet ahead of the bow. Great masses of water were thrown upon the decks, and not all of it was thrown off, immense quantities having adhered and frozen to everything touched, as our illustrations will amply testify. During the night a seagull alighted on the after deck, and was found there frozen in the morning. The main features of the test are shown in the table.

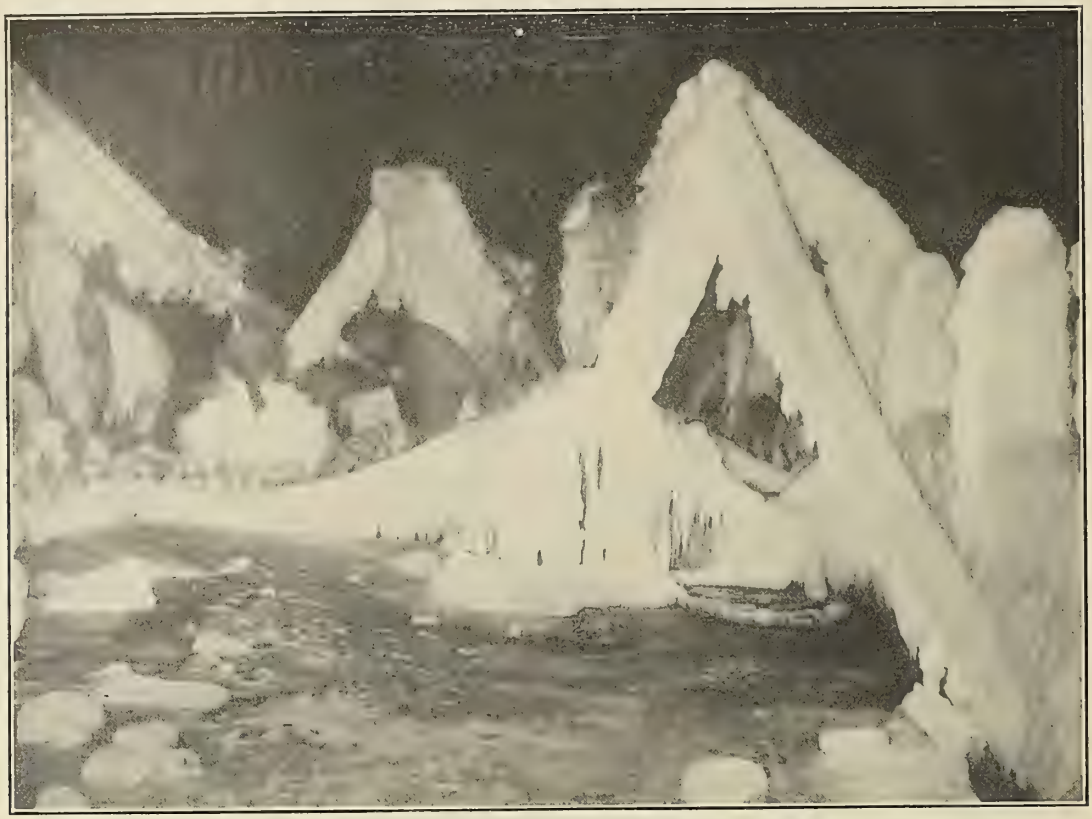
In addition to the tests for speed and endurance were tests of the steering gear, it being reported that the vessel turned in little more than her own length.

ICE ON FORWARD 12-INCH GUNS AND TURRET, U. S. S. VERMONT, DECEMBER 8, 1906.

THE SHIP.

The *Vermont* is a first class battleship of 16,000 tons displacement, measuring 450 feet on the waterline, with a beam of 76 feet 10 inches, a mean draft of 24 feet 6 inches and a length over all of 456 feet 4 inches. She has been built under contract with the Fore River Shipbuilding Company, Quincy, Mass., dated June 20, 1903, the act authorizing her construction having been approved March 3, 1903. The keel was laid May 21, 1904, and the vessel launched August 31, 1905.

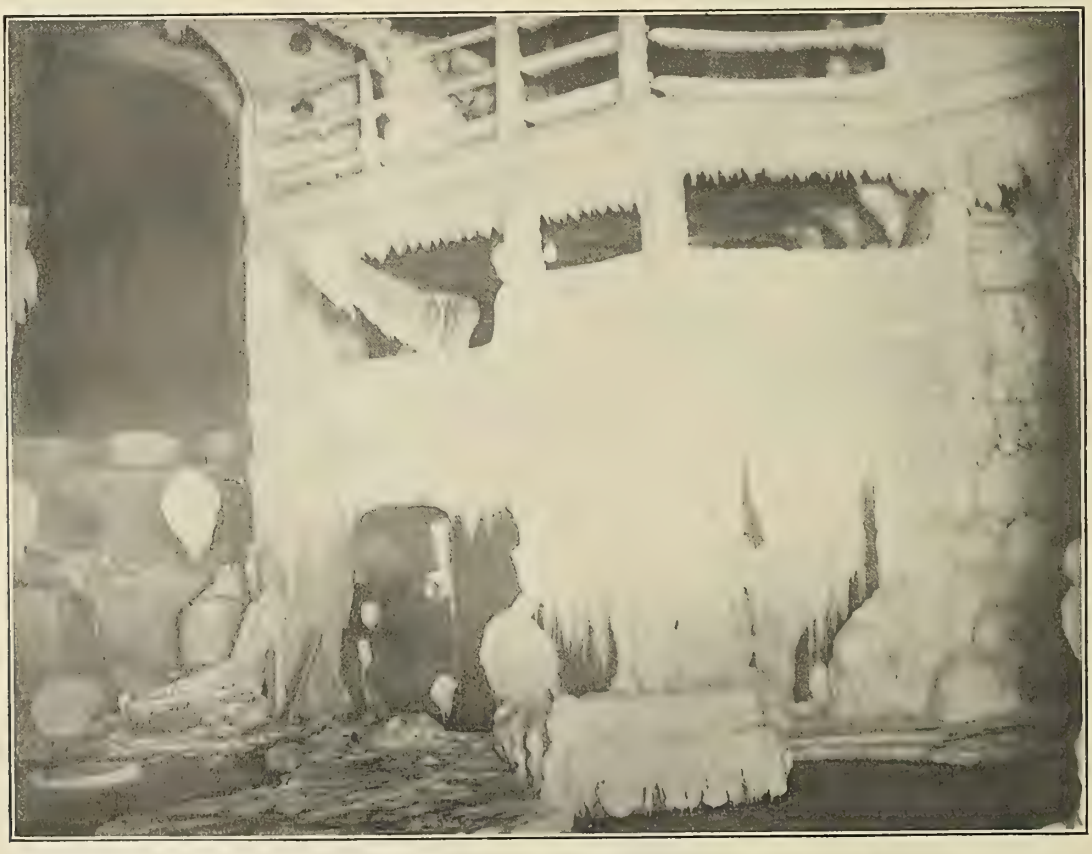
The battery consists of four 12-inch guns, mounted in pairs in turrets on the center line forward and aft; eight 8-inch guns, in pairs in turrets on the broadside; twelve 7-inch rapid fire guns,



THE FORWARD DECK. IN CENTER IS A LIFE BOAT. AT RIGHT ARE DAVITS AND STANCHIONS.

in an armored casemate, and fifty smaller rapid fire guns of varying sizes. There are four 21-inch submerged torpedo tubes.

The waterline armor belt has a thickness of 9 inches. The 12-inch barbettes are plated with 10 and 7½-inch steel, with turrets of 12 and 8-inch plates. The 8-inch barbettes are 6 inches and 4 inches thick, front and back, respectively, with turrets 6½ and 6 inches. The protective deck amidships is 3 inches thick on the slopes, and 1½ on the flat; at the ends it is 3 inches.



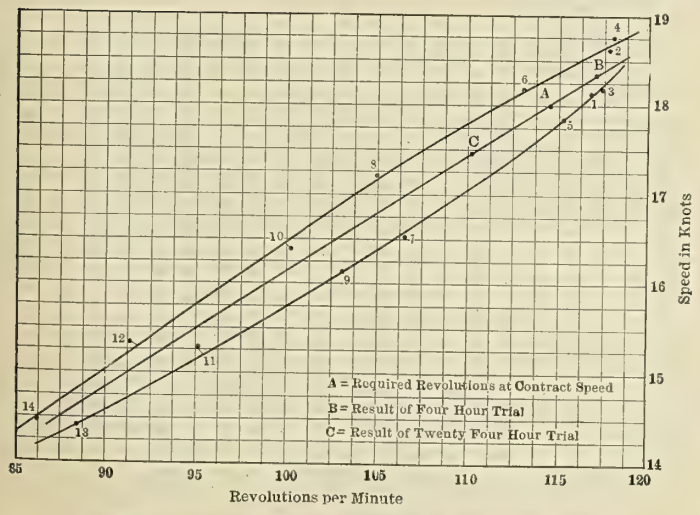
ICE ON FORWARD BRIDGE AND SUPERSTRUCTURE AT END OF RUN, DECEMBER 8, 1906.

Standardization trial, Dec. 5.		Four-hour run Dec. 7.	
Run No.	R. P. M.	Speed knots.	R. P. M.*	Speed knots.
1	116.71	18.118	116.513	18.250
2	117.73	18.64	119.010	18.581
3	117.42	18.20	119.013	18.581
4	118.09	18.76	118.210	18.476
5	115.27	17.857	118.050	18.453
6	113.08	18.191	117.650	18.410
7	106.48	16.529	117.137	18.333
8	104.95	17.176	117.693	18.406
9	103.11	16.143	117.440	18.376
10	100.20	16.4	116.267	18.222
11	95.24	15.274	116.417	18.240
12	91.38	15.33	117.423	18.372
13	88.53	14.42	115.783	18.153
14	86.1	14.46	115.567	18.126
			116.723	18.282
			114.973	18.045
Average			117.12	18.33

Propulsion is by two four-cylinder triple expansion engines with a designed horsepower of 16,500, furnished with steam by twelve Babcock & Wilcox watertube boilers. The cylinder diameters are respectively 32½, 53, 61 and 61 inches, with a stroke of 48 inches. The grate surface aggregates 1,100 square feet, with 46,750 square feet of heating surface, the ratio being 42.5 to 1. The normal coal supply of 900 tons can be increased when necessary to 2,200 tons. The complement includes 881 officers and men.

*Readings fifteen minutes apart.

THE UNITED STATES BATTLESHIP VERMONT PROCEEDING TO SEA FOR CONTRACTORS' TRIAL TRIPS.



SPEED-REVOLUTIONS CURVES FROM STANDARDIZATION RUNS.

A SUMMARY OF SCOTCH SHIPBUILDING IN 1906.

BY BENJAMIN TAYLOR.

If, when writing a year ago, I had to say that the shipbuilding output of 1905 had marked that year as a record one, what shall I say of 1906? It has exceeded all its predecessors, not only in gross output, but also in the production of sea-monsters. Naval architecture and marine engineering attained in it a height never before reached. The total production of the world in the year which has just closed may be taken at 2,792 vessels of 3,360,000 tons, as compared with 2,239 vessels of 2,945,000 tons in 1905; and the engine power at 3,160,000 I.H.P. as compared with 2,470,000 I.H.P. in 1905; and yet 1905 was a record year. The United Kingdom, as usual, heads the list with 1,421 vessels of 2,002,570 tons and 1,845,990 I.H.P., and of the United Kingdom's proportion, 511 vessels of 658,830 tons and 670,431 I.H.P. were produced in Scotland.

It is with Scotland I am chiefly concerned, and the figures relating to this center I take from *The Glasgow Herald,* knowing personally that these are carefully compiled and are thoroughly reliable. Thus, then, Scotland has turned out one-third of the new shipping produced in the United Kingdom in 1906, and considerably more than one-third of the engine power; also Scotland has produced nearly one-fifth of the entire new tonnage produced in the world. On the Clyde alone we have turned out within a small fraction of 600,000 tons—not only more than in any other shipbuilding center in the United Kingdom, but 130,000 tons more than the whole of the United States, and 230,000 tons more than all Germany. That is a record worthy of mention. The actual tonnage produced on the Clyde in 1906 is shown in the following table, in comparison with the output of 1905:

	1906.			1905.	
Builders.	Ships.	Tons.	I.H.P.	Tons.	I.H.P.
Russell & Company.....	14	63,338	.....	71,540	.....
John Brown & Co.....	7	46,387	108,900	20,606	45,000
Wm. Denny & Bros.....	16	40,632	44,200	30,202	54,300
Wm. Hamilton & Co.....	9	35,369	.....	31,282	.....
Barclay, Curle & Co.....	6	33,608	25,310	36,354	26,332
D. & W. Henderson & Co.	6	33,187	23,950	35,328	24,200
Scotts' S. & E. Co.....	11	33,180	50,100	29,182	28,800
Chas. Connell & Co.....	7	31,106	.....	39,429	.....
Caird & Co.	4	26,778	17,000	25,801	30,000
A. McMillan & Son.....	8	23,767	.....	21,409	.....
A. Stephen & Sons.....	6	22,982	18,700	22,241	18,300
Grangem'h Green'k Co...	5	22,112	.....	18,046	.....
Wm. Beardmore & Co...	2	21,000	4,000	4,196	2,850
Fairfield Company	5	20,063	29,380	37,835	56,500
A. Rodger & Co.	8	19,895	8,300	26,734	11,100
London & Glasgow Co...	3	13,154	13,100	4,295	5,000
Clyde Ship & Engine Co.	5	11,096	10,880	11,308	18,000

Builders.	Ships.	1906. Tons.	I.H.P.	1905. Tons.	I.H.P.
Napier & Miller	3	10,740	.....	15,381	.....
Ross Duncan & Co.	3	10,710	11,635	2,660	12,170
Ailsa Company	34	9,368	.....	5,394	.....
Mackie & Thomson	19	7,920	.....	2,913	.....
John Reid & Co.	10	7,664	.....	1,293	.....
D. J. Dunlop & Co.	5	6,884	7,870	1,670	1,720
*D. Rowan & Co.	..	.....	45,850	.....	43,160
*Dunsmuir & Jackson	..	.....	41,325	.....	24,480
*Rankin & Blackmore	..	.....	23,200	.....	18,300
*G. J. Kincaid & Co.	..	.....	18,000	.....	20,790
All other firms	176	47,901	104,900	44,751	77,545
Totals	372	598,841	606,600	539,850	518,547

A large increase in the Clyde marine engineering returns is accounted for by the turbines for the *Lusitania.* John Brown & Company's total of 108,900 I.H.P. is second in the world for the year. An interesting turbine contract was the re-engining by A. & J. Inglis of the Khedive's yacht *Mahroussa.*

Two years ago Russell & Company, Port Glasgow, had the largest tonnage output in the world. In 1905 they were fifth in the world, but first on the Clyde. In 1906 they are seventh in the world, but they are still first on the Clyde. John Brown & Company, Limited, Clydebank, have the second largest tonnage, but are actually first so far as the value of the work is concerned. The *Lusitania,* built by them, is a vessel worth numbers of ordinary steamers, and they had three other turbine steamers in their launches, also the transport steamer *Northbrook* and two Irish Channel turbine steamers. William Denny & Bros., Dumbarton, who come third, have three turbines, two large twin screws, one large single screw, also three sailing schooners for Buenos Ayres. William Beardmore & Co., Dalmuir, whose 1905 output was 4,196 tons, in 1906, with the launch of H. M. S. *Agamemnon,* have 21,000 tons.

In 1901, for the first time, Clyde shipbuilders launched a total of over half a million tons, and this marked what was then said would be the record for a long time to come. Five years later the launches come within 1,159 tons of 600,000, an increase of 100,000 tons in five years. There is not, however, this time any Clyde firm with a tonnage equal to the large Wallsend company's. The important fact is not that no Clyde firm has a total of over 63,338 tons, but that the work of the whole district shows a very large increase. The increase, while it brought the tonnage near to 600,000 tons gross, was scarcely so rapid as that of 1905. Since the depression in 1904, there has been an increase of 180,971 tons. Previous to that depression the highest total reached was in 1902, when 516,977 tons were floated. Last year is better than the best of the previous good years by 81,864 tons.

Of the 372 vessels launched on the Clyde in 1906, the most interesting was the Cunard steamer *Lusitania* at Clydebank—one of the two largest and fastest vessels in the world. After the *Lusitania* was the battleship *Agamemnon,* built by Beardmore, and the largest war vessel ever built on the Clyde. Then there are the Fairfield Company's "Empress" liner for the Canadian Pacific Railway Company, Barclay Curle & Company's new Anchor, City and Hall steamers; D. & W. Henderson & Company's two mastless steamers for A. Holt & Company, many dredgers built at Renfrew, Paisley and Port Glasgow, and many trawlers built at Govan, Bowling and Ardrossan; and four large schooners built for Buenos Ayres, three at Dumbarton and one at Port Glasgow. The different types of vessels built were as follows:

Type.	No.	Tonnage.
Single Screw Steamers	130	361,901
Twin Screw Steamers	27	120,700
Turbine Steamers	8	48,430
Barges and Lighters	86	16,680
Warships	1	16,500
Dredgers	15	11,125
Paddle Steamers	13	7,943
Steam Fishing Vessels	30	6,430
Sailing Vessels	8	4,457
Stern Wheel Steamers	9	1,884
Tugs	18	1,763
Yachts (steam and sail)	10	562
Launches, motors, &c.	15	286
Lightships	2	180
	372	598,841
Of which, steam vessels	274	582,506
sailing vessels	98	16,335

*Built machinery only.

The tendency nowadays is towards higher pressure of engines in ocean tramps. With higher pressures a boiler requires the best material and the highest class of workmanship. With improved appliances, electric driving, hydraulic and pneumatic plant and other machine tools, our marine engine and boiler works are now producing a very high class of output. The position of the Scotch multitubular boiler as an economical and safe steam producer at high pressures has been re-established on a sound basis.

The five-crank engine is little heard of now, and the quadruple expansion engine during the past year has made a definite advance. With the introduction of the triple expansion engine at 140 or 150 pounds working pressure, the boiler and furnace difficulties were immense, and various methods were tried of placing three cylinders over two cranks, to save space. Many experiments were made of placing four cylinders over three cranks to save space, and small boilers were resorted to in order to overcome the difficulty of handling and working the heavier plates required for the higher pressure with boilers of normal size. All this is now changed. High pressures and the necessary heavy plates are no longer difficulties, and in another year or two the triple expansion engine will largely give place to the quadruple, and the twin screw will supplant the single screw. There are now few important passenger lines which do not include twin screw vessels in their fleets, and there are now at work no less than 1,626 steamers having two or more screw propellers, and with a collective measurement of 4,523,779 tons.

With the introduction of the turbine system of marine engine a great impetus was given to the use of multiple screw propellers. Two or more propellers have been fitted on each line of shafting connected with turbine engines, in order to utilize the propulsive value of that type of marine machinery; but recent experience has not proved that there is any advantage in having more than one propeller of suitable form on each shaft. In most turbine-driven steamers there are three lines of shafting, and in the *Lusitania* and *Mauretania,* now building for the Cunard Company, there are four.

At the close of the year 1906 there were 32 turbine steamers of 99,036 tons belonging to the mercantile marine of Great Britain, all of them employed in the carriage of passengers. Their speeds range from about 15 knots to 23½ knots. There are also five turbine yachts, of 2,526 tons. The following were the turbine steamers produced during the year 1906:

Vessels.	Tons.	Builders.
Lusitania	32,500	John Brown & Company.
Mauretania	33,200	Swan, Hunter & Wigham Richardson.
H. M. S. *Dreadnought*	17,900	Portsmouth dockyard.
Rewa	7,003	Wm. Denny & Brothers.
Creole	6,000	Fore River Company.
Yale	4,500	Delaware River Company.
Governor Cobb	2,525	Delaware River Company.
St. George	2,456	Cammell, Laird & Company.

St. Patrick	2,387	John Brown & Company.
St. David	2,387	John Brown & Company.
Immingham	2,009	Swan, Hunter & Wigham Richardson.
Marylebone	1,972	Cammell, Laird & Company.
Viper	1,713	The Fairfield Company.
Kingfisher	871	Wm. Denny & Brothers.
Duchess of Argyll	583	Wm. Denny & Brothers.
Atlanta	486	John Brown & Company.
Five Destroyers	1,500	J. S. White & Company.
Three Destroyers	681	J. I. Thornycroft & Company.
	120,973	

The largest merchant ships of the year are the new Cunarders. In 1905 the largest vessel was the *Kaiserin Auguste Victoria,* built by the Vulcan Company; the second largest, the *Amerika,* built by Harland & Wolff; and the third largest the *Carmania,* built by John Brown & Company. In 1906 we have:

Vessels.	Tons.	Builders.
Mauretania	33,200	Swan, Hunter & Wigham Richardson.
Lusitania	32,500	John Brown & Company.
Adriatic	25,000	Harland & Wolff.
Kronprinzessin Cecilie	19,400	The Vulcan Company.
Empress of Ireland	14,406	Fairfield Company.
Araguaya	10,537	Workman, Clark & Company.

There has not been much variation in the structural design of sailing ships during the past fifty years. The designs of steamers, however, have been the subject of continued and radical change. Formerly steamers were usually flushdeck, often with awning decks or spar decks. Raised quarter decks, long poops, short bridge houses, and topgallant forecastles then came into use. Next came part-awning decks, raised fore decks, and other discontinuous systems of main structure and erections. In turn they gave way to poop, bridge and forecastle erections in the "three island" type of steamers. Later the shelter-deck type found favor, and many such are now being built, as well as spar-deck and three-deck vessels with short poops and forecastles and long bridges. The omission of decks and tiers of beams without loss of structural strength was accomplished first by web frame arrangements, and latterly by the use of deeper frame girders. The turret-deck and trunk-deck types, which have been frequently adopted, represent modifications from the normal type, both in regard to external form and structural combination. The cellular double bottom for water ballast grew out of the McIntyre tank fitted in some of the early screw colliers. It is now, together with peak tanks, a constant feature in steamship design. This provision for ballasting is now supplemented by deep midship tanks. Of late the McGlashon side tanks and the Harroway-Dixon wing tanks have been introduced to improve stability when water ballast is carried.

	Sail			Steam		
	Vessels.	Tons.	Mean.	Vessels.	Tons.	Mean.
1890	84	121,015	1,441	632	1,076,220	1,702
1891	142	214,352	1,509	629	941,031	1,496
1892	164	282,308	1,721	493	809,740	1,642
1893	79	112,381	1,423	389	729,911	1,875
1894	58	78,389	1,352	469	873,757	1,862
1895	29	36,999	1,276	463	919,308	1,985
1896	39	39,033	1,001	579	1,082,472	1,868
1897	19	19,713	1,038	485	887,998	1,831
1898	6	2,569	428	684	1,301,325	1,902
1899	8	5,900	738	647	1,357,112	2,099
1900	6	6,605	1,101	645	1,452,802	2,251
1901	14	14,868	1,062	534	1,447,787	2,713
1902	19	36,384	1,915	537	1,376,327	2,565
1903	16	19,300	1,206	542	1,128,887	2,083
1904	22	20,742	943	535	1,176,638	2,197
1905	3	2,461	820	667	1,516,193	2,273

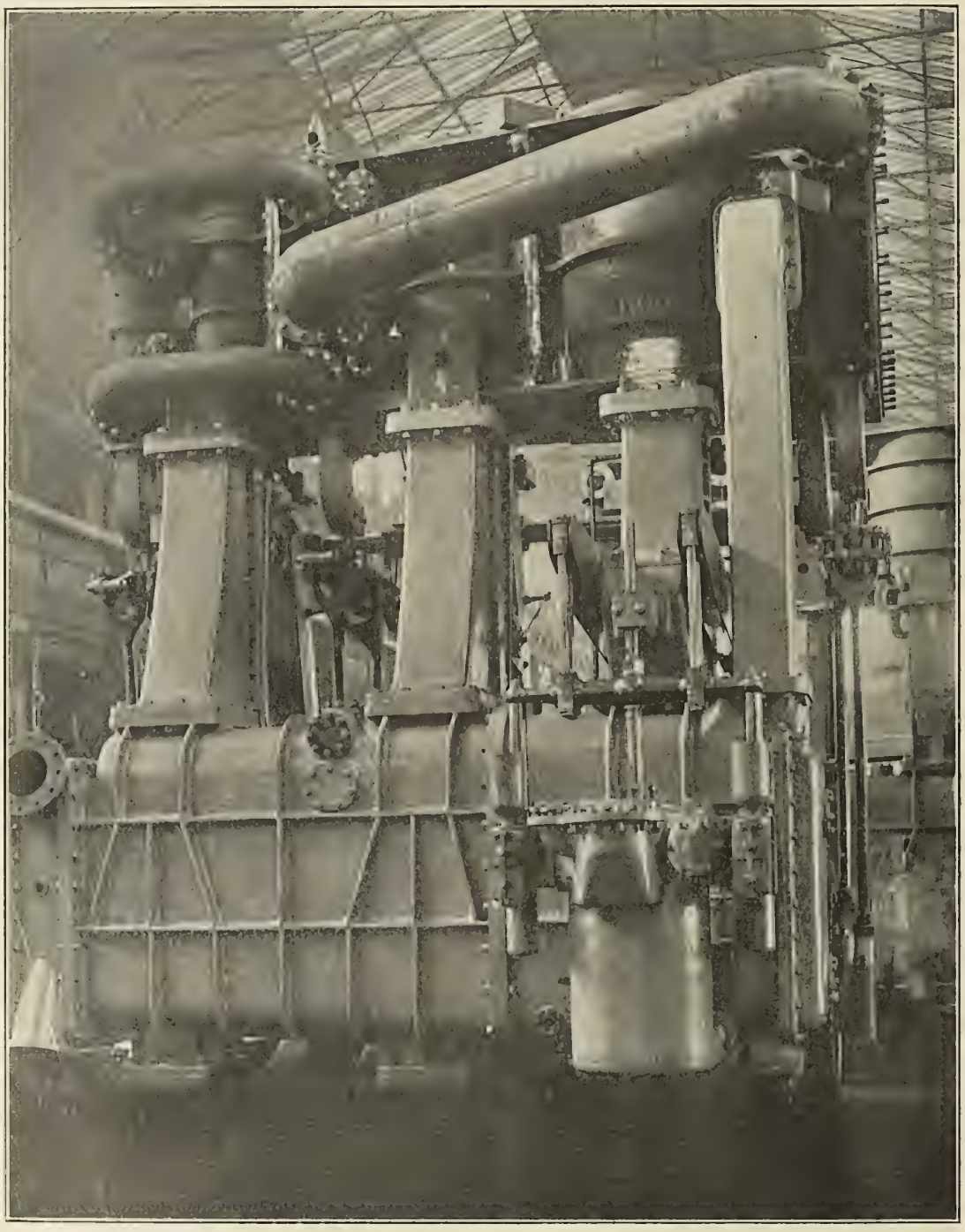
Sailing vessels were, until twelve years ago, still being constructed in great numbers. But during more recent years the building of sailing vessels has almost ceased in the United Kingdom, as will be seen by the foregoing table, showing the number and tonnage (gross for steam and net for sail) of vessels of 100 tons and upwards built in the United Kingdom, as recorded by Lloyd's.

In the early sixties wooden ships of large size were still being built, but iron was then quickly taking the place of wood. About the same time composite shipbuilding was being introduced, and for several years previous to the opening of the Suez Canal the composite system was largely employed in the construction of sailing vessels trading to the Far East, and especially in the China tea trade. The opening of the Suez Canal transferred the Far Eastern trade to steamers. This further diminished the demand for sailing ships, and to-day most of the carrying trade of the United Kingdom in sailing ships is to Western American ports. Between 1850 and 1900 the sailing ship grew from an average size of about 800 tons to one of about 2,000 tons, and some sailing vessels now afloat are even larger. One German sailing ship is of 5,000 tons, and has five masts. Large sailing ships built and owned in Great Britain have usually been rigged with four masts. From the time that mild steel came into use for shipbuilding (1885) both sailing ships and steamers have for the most part been built of that material. At present iron is not very largely used, except for certain parts, such as decks, which are especially liable to corrosion.

The majority of the contracts booked during the past year by Clyde builders will leave smaller profits than in some previous years when fewer contracts were booked, as material has so much advanced. In the summer and autumn there were evidences of slackness, but the berths filled up, and at present there are few vacancies. During the past three months, although there have been a great many launches, it is doubtful if the tonnage on hand has been decreased very much. Some vessels ordered over a year ago have not yet been launched, the owners not wishing immediate delivery, while other orders have come in since and are now taking shape. In the work on hand the most important examples are at Fairfield and Clydebank. At each of these yards there is one cruiser on the stocks—the *Indomitable* at Fairfield and the *Inflexible* at Clydebank. The Fairfield Company are completing H. M. S. *Cochrane* (launched in 1905), and are building two large turbine steamers, each of 10,000 tons, for the Egyptian Steamship Company, and a coasting steamer of 1,200 tons. John Brown & Company, Limited, are building, besides the cruiser, two cargo steamers and a steamer for the Lancashire & Yorkshire Railway Company. The big Cunarder is being fitted out in their docks, and will provide employment for at least six months yet. At Dalmuir, Beardmore & Company are completing the *Agamemnon* and the Pacific Steam Navigation Company's vessel *Quillota,* and are building two other steamers for the same owners and two for the new Australian mail service. Charles Connell & Company have five large steamers on the stocks. Barclay, Curle & Company have five vessels, among them being a large steamer for the Ellerman Line, another for the Furness-Withy Line, and a vessel of 10,000 tons for the Allan Line. Alex. Stephen & Sons, Linthouse, have also a steamer for the Allan Line, and vessels for Trieste, London, Glasgow, and the Howard Steamship Company. Mackie & Thomson have a considerable number of trawlers on the stocks, and the London & Glasgow Shipbuilding Company a twin-screw steamer of 5,500 tons for Marseilles. A. & J. Inglis are making progress with a turbine yacht for King Edward, and a large train-carrying vessel for South America. William Chalmers & Company, Rutherglen, are building two ferries for the Argentine government. The work on hand in Denny's yard at Dumbarton consists of a large

turbine steamer for the Union Steamship Company of New Zealand, and two turbine steamers for the cross-channel service of the South Eastern & Chatham Railway Company. This firm has also on order two turbine steamers for Japan, and government orders for two high speed torpedo boat destroyers. At Greenock, Caird & Co. are building a steamer of 6,500 tons for the Union Steamship Company of New Zealand, while Scotts' Shipbuilding & Engineering Company has orders for two steamers of 7,600 tons for Glasgow owners, and a steamer of 8,000 tons and five lighters for other owners. Wm. Hamilton & Company have a considerable amount of work, their contracts including a large steamer for the Hamburg-American Line. They have altogether five steamers for Glasgow owners, and three for other owners. Ferguson Brothers have two dredgers building, and among their other orders are a powerful dredger for New Zealand, and a large sand-pump dredger for the Thames Conservancy Board. Murdoch & Murray have still some steamers to build for the Amazon.

Altogether the New Year opens with a large amount of shipbuilding work on hand in this district, even if no new contracts come in during the spring months. But the output is not likely to be so large as in 1906, because, while the cost of building cargo boats has been materially raised, there has not been a corresponding advance in freights. There is a lot of sea traffic to carry, but already there are too many vessels to carry it.



BACK VIEW OF THE TRIPLE EXPANSION ENGINE OF THE SATILLA, SHOWING CONDENSER AND AIR PUMP.

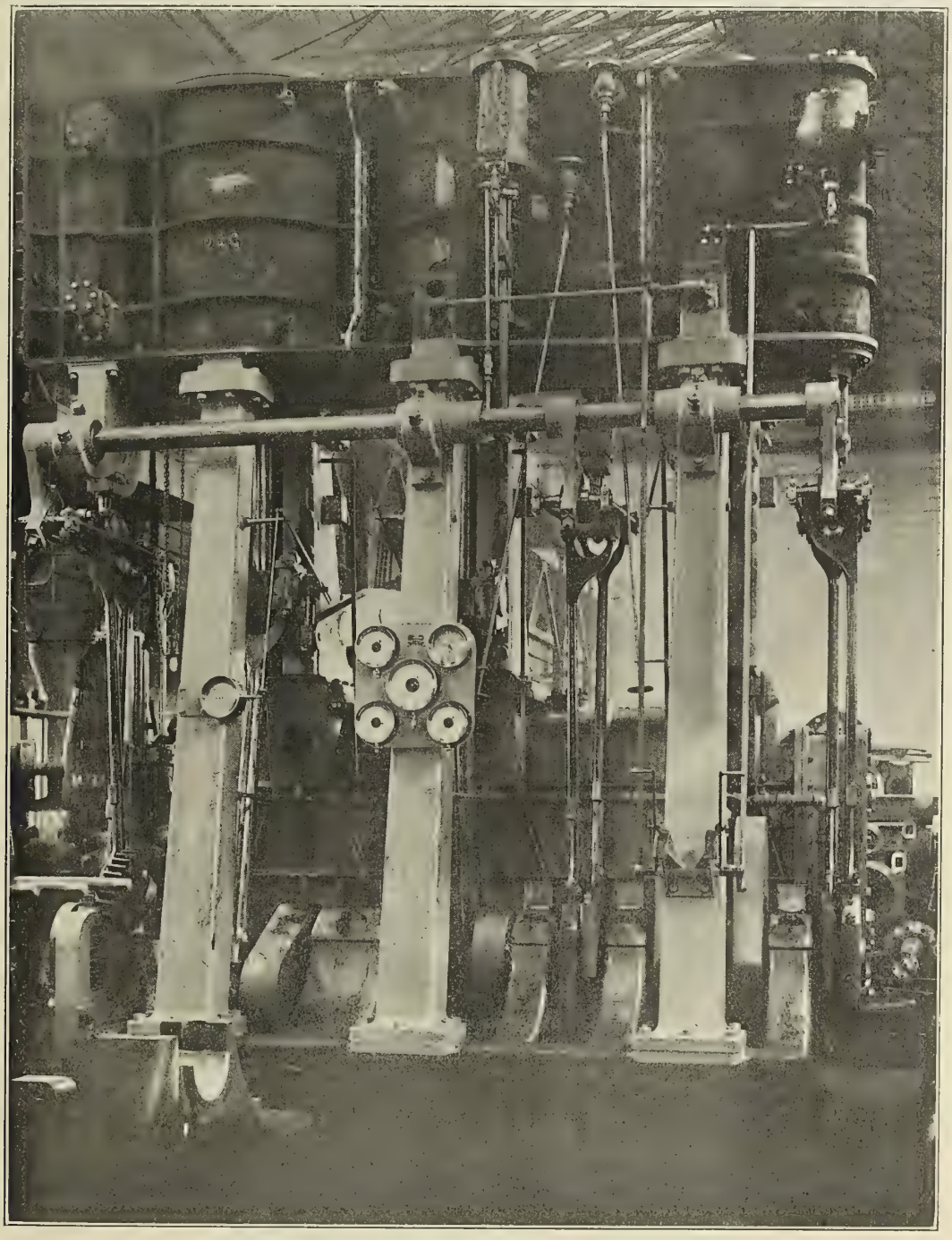
THE STEEL FREIGHT STEAMER SATILLA.

The four freight steamers *Satilla, Ocmulgee, Ogeechee* and *Ossabaw,* built by the Fore River Shipbuilding Company, Quincy, Mass., for the Brunswick Steamship Company, operated by the Atlanta, Birmingham & Atlantic Railroad Company, have attracted considerable interest on account of the peculiar arrangement adopted for the cargo spaces and the placing of machinery. In the latter respect they follow in large measure the methods adopted on the Great Lakes, the engines being placed at the

extreme after end of the vessel. The *Satilla* was launched August 21 and the *Ogeechee* November 5, 1906.

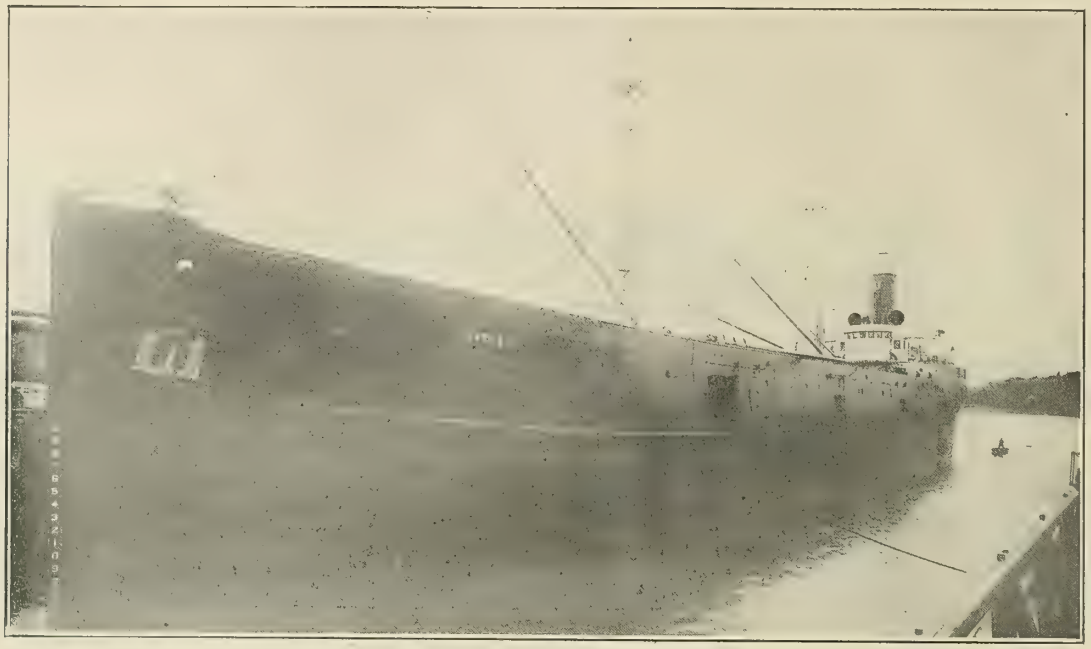
The ships are constructed of mild steel, and have a length over all of 313 feet, a breadth molded of 40 feet and a depth of 25 feet 6 inches, the displacement being about 5,000 tons. They have been designed to carry a maximum of freight on an unusually light draft, and in order to minimize broken stowage the pillars of the cargo holds have been worked out on the girder system, with two large columns in each hold, connected at the head to a continuous deck girder. Special consideration has been given to the question of strength, which is in excess of that usually provided in freight steamers. The vessels have a straight stem and semi-elliptical stern.

There are three large cargo holds provided with four hatchways suitably arranged for the rapid handling of freight. Two of these hatchways measure 16 by 14 feet, while the other two are 12 by 14 feet. In each case the dimension of 14 feet is transverse. In addition to these hatchways, there are four cargo ports on each side of the vessel, measuring in the clear about 10 by 7 feet and arranged with sliding trolley doors. The cargo holds are separated from each other by steel watertight bulkheads, which, with the other bulkheads on the vessel, divide her into seven separate watertight compartments. These have been so arranged that any two adjacent ones may be flooded without overcoming the reserve buoyancy. These bulkheads would also act as effective barriers to the spread of a fire.



FRONT VIEW OF THE PROPELLING ENGINE OF THE SATILLA, SHOWING LIGHT BOX COLUMNS.

The vessel is fitted with two steel pole masts, extending about 60 feet above the deck, and each carrying four derricks, giving a total of two to each hatchway. The derrick booms have a length of 40 feet, and are capable of handling loads up to 7½ tons. The derricks are stepped on strong steel tables, and are provided with powerful winches for handling the cargo in the most expeditious manner possible. There are eight of these winches in pairs, one winch for each derrick boom.



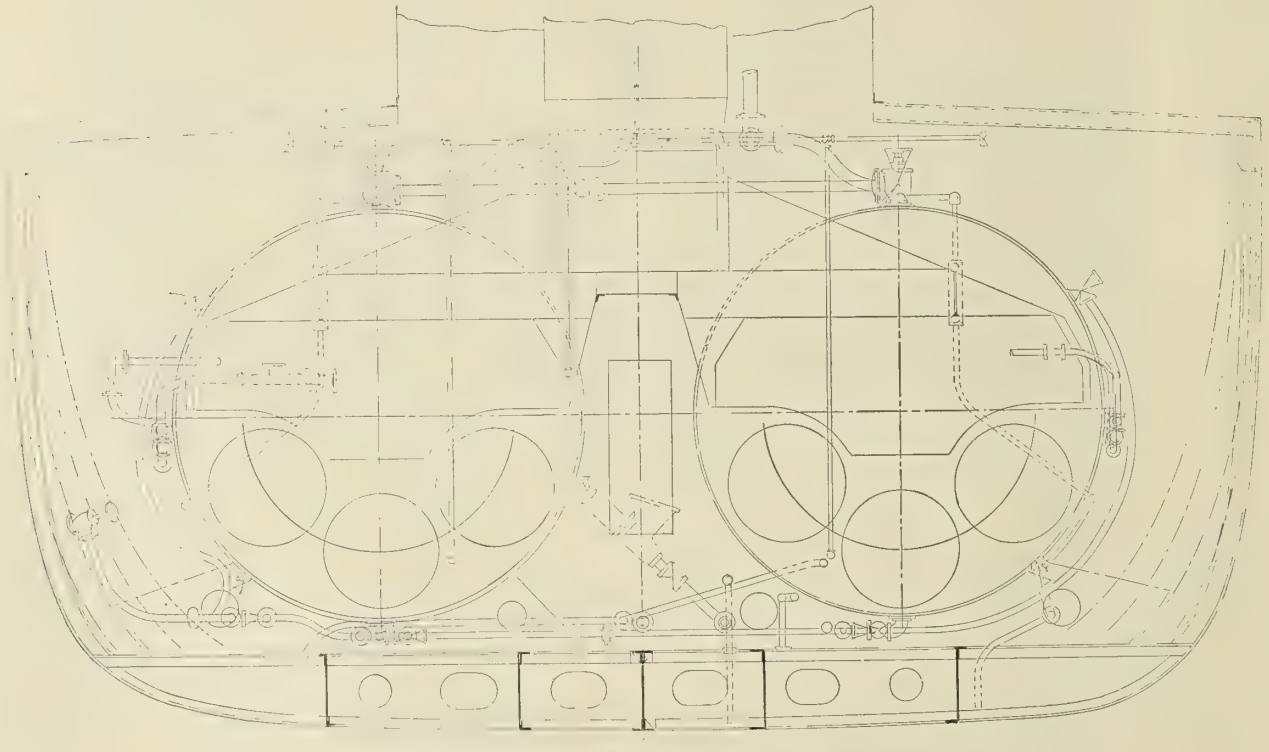
THE NEW CARGO STEAMER SATILLA, RESEMBLING A LAKE STEAMER.

To insure proper trim when the vessel is steaming light, deep trimming tanks have been arranged forward on both sides of the collision bulkhead. The water in these tanks would balance to any necessary extent the weight of the machinery, all of which is placed in the after fifth of the vessel's length.

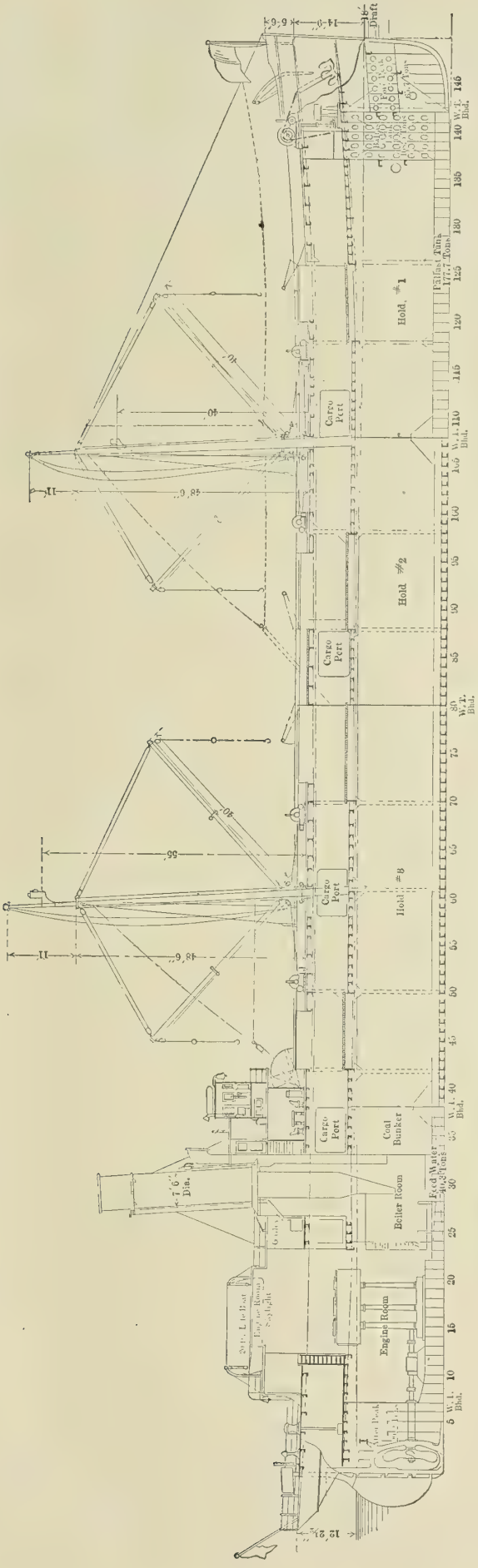
The propelling machinery consists of one triple expansion surface condensing engine supplied with steam by two single ended Scotch boilers, the power being sufficient to give a continuous speed of 10.5 knots. The engine has cylinders measuring 18, 28½ and 48 inches in diameter, with a stroke of 40 inches. The high-pressure and intermediate cylinders are fitted with piston valves, and the low-pressure with a flat slide valve. At full speed the engine makes 90 revolutions per minute. The grate surface of the two boilers is 130 square feet, and the heating surface 3,920 square feet, giving a ratio of 30.15 to 1. The products of combustion are discharged through a single stack with an outside diameter of 7 feet 6 inches.

The propeller has a pitch ratio of 1.083, the diameter being 12 feet and the pitch 13 feet. The material is cast iron, in a single solid casting.

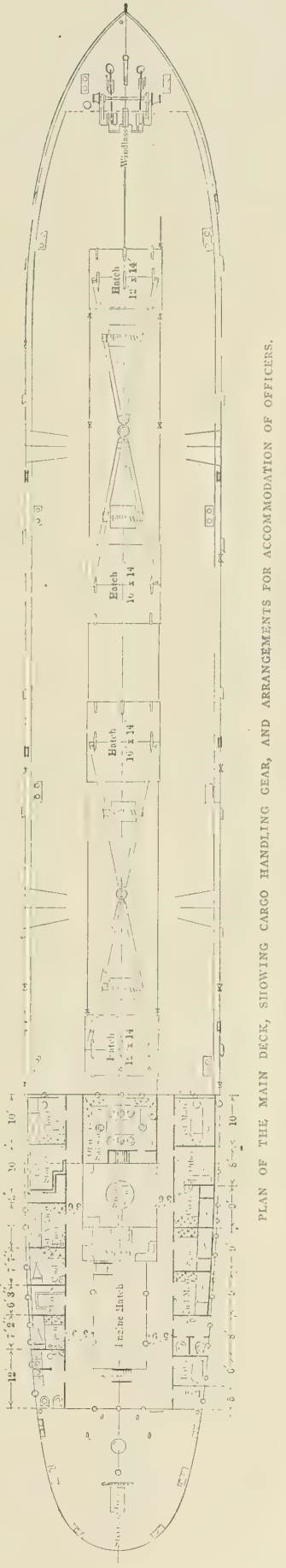
The usual pumping, drainage, sanitary and fire main system has been arranged, while an electric light installation of ample power has been installed. Steam steering and screw hand-gear have been fitted, with steering stations in the pilot house and on the quarter deck aft. There is also a powerful steam warping capstan. The anchor handling arrangements include a steam windlass, with operating engines placed on the main deck forward under cover.



TRANSVERSE SECTION OF THE SATILLA, SHOWING BOILERS, UPTAKES AND PIPING.



INBOARD PROFILE OF THE FREIGHTER SATILLA, SHOWING LOCATION OF MACHINERY AND CARGO HOLDS, WITH DERRICKS AND HATCHES.



PLAN OF THE MAIN DECK, SHOWING CARGO HANDLING GEAR, AND ARRANGEMENTS FOR ACCOMMODATION OF OFFICERS.

The officers' quarters are located in the steel superstructure built around the engine and boiler casings, and are provided with especially well-lighted and ventilated state rooms for the officers and engineers. Their dining saloon is placed at the forward end of the superstructure amidships, and provides seats for eight officers. The crew, firemen, oilers and water tenders are berthed on main deck in way of machinery space.

The superstructure is decked over, thus forming a bridge deck on which the life boats are stowed. The pilot house and captain's room are at the forward end just in front of the funnel. The captain's suite comprises a bed room and sitting room, with a gangway leading to the dining saloon.

COLD STORAGE ON BOARD SHIP.

PART IX.

BY SYDNEY F. WALKER, M. I. E. E.

FAULTS IN EVAPORATING COILS.

Faults in evaporating coils are very similar to those in condenser pipes. There may be leaks at joints, allowing the refrigerant to leak out, with the results explained, and if the evaporator is employed to cool brine, which is used for the cold chambers, and the system is allowed to stand for a certain time during the day, and even in some cases when not, a small quantity of the brine will probably work its way into the evaporator coils, and will give rise to the troubles already described. With ammonia, a leak into the brine tank is made manifest by the smell and a litmus paper test, and should be immediately seen to by pumping the refrigerant out of the evaporator coils, emptying the brine tank, and examining all joints, if necessary, with air pressure, as described.

Another source of trouble with the evaporator coils has already been alluded to, the deposit on the outside or the inside of the pipes. Where the evaporator coils are carried right into the cold chamber, they very frequently become covered with a coating of ice. This should be cleared off periodically. Where the evaporator is employed to cool brine in a brine tank, the salts contained in the brine are sometimes deposited on the outside of the pipes, forming a crust, as explained in connection with the condenser coils, which resists the passage of the heat from the brine to the refrigerant, with the result that a smaller quantity of work is done, a smaller quantity of heat is lifted at each stroke of the compressor, and either the compressor must run faster, or the temperature of the brine will go up. The same thing will happen if there is a deposit of oil or any other substance on the inside of the evaporator pipes.

The fact that the evaporator coils are working badly will be known by two things, the temperature of the room or the brine, or the air it is cooling will rise, and the gage pressure on the end of the coils will also rise, because the gas is not properly expanded down. The remedy is, to examine the evaporator coils on the outside, periodically, and to clean off any deposit that is formed. This applies also to the condenser coils, and the cleaning off should be done by means of a brush which goes right down into the condenser, or the evaporator tank, and gets at every part of each of the pipes to be cleaned.

Where the deposit is on the inside of the evaporator coils, there is only one remedy, disconnection and blowing through with steam and air, as already described, though the matter may be temporarily put right by increasing the speed of the compressor, where the compressor will stand it, or by opening the regulator valve widely where there is a margin available. The piston speed of refrigerating compressors is very low, usually not more than 180 feet per minute, and it is not wise to run them faster, because it is apt to lead to heating of the compressor. But on occasion they may be run slightly faster, providing that it is done with care, and where it is a case of necessity. When this is done, however, the compressor should be very carefully watched for any heating, and anything of the kind immediately attended to.

It may happen that one or more of the refrigerator coils are not doing their work, and from that cause the quantity of heat taken out is less than it would be, approximately in proportion to the number of dead coils. The evaporator coils that are not doing their work may be known by the absence of the frost on the coils themselves, or where they are immersed in a brine tank, on the short exposed piece of pipe leading to the header. Where this happens, the faulty coils should be temporarily bridged over, disconnected from the service, and examined, care being taken, in the case of ammonia, to remove the ammonia either from the faulty coils themselves, or, if that cannot be done, from the whole of the evaporator coils, before disconnecting.

TROUBLES WITH COMPRESSOR VALVES.

Marine engineers hardly need reminding that valves give trouble. The compressor valves, as explained in the descriptive part of these articles, are kept on their seats by powerful springs, the valve box either being part of the casting forming the end of the compressor cylinder, or in some cases being screwed on the outside. In all cases there is the usual valve rod moving in and out as the valve opens and closes, and there is the usual trouble that the valve rod may be bent, or that grit may get between the valve and its seat. In either case leakage may result; leakage of the suction valve meaning the expulsion of a portion of the charge, in place of its being compressed to its proper pressure; and leaking of the delivery valve meaning a reduction of the pressure at which the gas is delivered to the condenser, since there will be a certain amount of suction, as the piston returns after the compression stroke. There is only one rule applying to this class of fault,—watch the working of the valves, and examine them as often as convenient. Usually their proper action, or the reverse, may be heard.

There is a more troublesome fault in connection with valves, where the valve rod is slightly bent, and that is, an intermittent sticking. The suction valve may not properly open on one stroke, while it may open on another, and the delivery valve the same. The result of this is, the action of the compressor is irregular, and this is shown by the throw of the gages. Watching the gages, as advised above, will in a great many cases show trouble in time.

The same remarks apply to leakage past the piston. This arises when the piston leathers are partly worn out, and the result is, the gas is not compressed to its proper pressure, the condenser pressure falling and the evaporator pressure rising. Again, when this happens, make an examination of valves and piston at the earliest opportunity, unless meanwhile it has been shown that the fall is due to some other cause.

If either valves or piston are suspected of leaking, the fact may be ascertained with a fair amount of certainty by closing the regulator valve, and continuing to run the compressor. As the gas is being gradually drawn over from the low pressure evaporator side to the condenser side, the pressure on the evaporator side will gradually fall, and in a certain number of revolutions which the manufacturers will give (in one case it is 200 revolutions), the pressure will come down about 80 percent—in the case of carbonic acid, from 25 atmospheres to 5 atmospheres. If the pressure does not come down, it is evident that the gas is leaking past the piston or the valves, and they should be examined.

TESTING THE GAGES.

Gages, unfortunately, sometimes vary, even the best, and when carefully handled, and it may therefore happen that misleading indications will be given. The only way to test the gages at sea, or anywhere away from a physical laboratory to which they can be sent, is by stopping the compressor, opening all the valves, and allowing the system to settle down. The whole of the

refrigerant then assumes one temperature and one pressure, the temperature of the brine tank, and consequently the gages at the condenser and at the refrigerator should indicate exactly the same. If they do not, comparison should be made between them, and the only thing that can be done is to bear in mind that there is this difference, and the "freezer" engineer may be guided in reading the indications of his gages by the fact that they do indicate differently.

When it is found that the gages do not indicate alike the earliest opportunity should be taken of either changing gages or having them tested. Gages of all kinds are very difficult indeed to construct accurately. In the United Kingdom, manufacturers keep standard test gages, which are frequently compared with those in service, and periodically sent to them for comparison with the standard instruments there.

FAULTS IN THE BRINE CIRCULATING SYSTEM.

Brine circulation is adopted, as explained in the early part of these articles, for two reasons. Where ammonia is the refrigerant, it is a very serious matter if any of it escapes into the cold chamber, where meat or other produce is stored. With carbonic acid this difficulty almost disappears. It quite disappears if a proper system of ventilation is employed, so that the air in the cold chamber is changed, and the vapors given off by the produce are carried away. In any case it would have to be a somewhat large leak that would cause any serious inconvenience.

The other reason for employing brine, and it is particularly applicable to shipboard work, is, that it enables the engineer to carry different holds or different cold chambers, at different temperatures, and all from one set or plant. The case is by no means infrequent where some of the holds are carrying, say, frozen mutton, while one or more of the others are carrying chilled beef. Frozen mutton may be frozen as hard as you please, and it is only a question of keeping the temperature low. With chilled beef the matter is quite different. A fall of temperature beyond a degree or two is just as fatal as a rise of temperature. In fact, a rise of several degrees of temperature, providing that the subsequent cooling does not take place too rapidly, will do far less harm than a fall of temperature. Anything in the nature of freezing, where chilled beef, fruit, or other substances that must not be frozen are carried, is fatal.

With brine circulation the engineer is completely master of the situation, provided that his plant is properly laid out, and that it is properly attended to. With this arrangement, as explained, the brine is cooled by the evaporator coils in one or more tanks, and the cooled brine is pumped to the brine grids in the different holds or cold chambers, where it extracts the heat, returns to the evaporator tank at a higher temperature, delivers up its heat, and commences its round again, and so on.

Brine again is employed because it has a lower freezing temperature than water. It is hardly necessary to point out that it would be impossible to circulate water at a temperature below freezing point, but the addition of any solid to water, providing the solid is properly dissolved, immediately lowers the freezing point. In the case of chloride of calcium, which is the substance nearly always employed, almost any degree of temperature can be carried, providing that the solution carries a sufficient percentage of the chloride. With 1 percent of chloride the freezing point of the solution is 31 degrees F.; with 5 percent it is 27½ degrees F.; with 10 percent it is 22 degrees F.; with 15 percent it is 15 degrees F.; with 20 percent it is 5 degrees F.; and with 25 percent it is —8 degrees F. From 15 to 20 percent is the strength of solution usually carried, where freezing temperatures are required, but there is no reason to carry this strength of solution, where the higher temperatures are carried for chilled beef, 29½ degrees F., and in the neighborhood.

It is a disadvantage to employ a too dense solution of the chloride for two reasons. In the first place, the greater the quantity of chloride in the solution, the lower is the specific heat. With 1 percent of chloride the specific heat of the solution is 0.996, practically the same as water. With 5 percent it has sunk to 0.964; with 10 percent to 0.896; with 15 percent to 0.860; with 20 percent to 0.834; and with 25 percent to 0.79, approximately. This means that with a 20 percent solution, approximately, the heat carrying power of a given quantity of the solution is 15 percent less than that of water, and this means that a larger quantity of the solution must be circulated to carry off the same quantity of heat from the cold chamber, the air, etc.

The other disadvantage is, the greater the density of the solution, the greater the tendency to deposit on the pipes in which the solution is circulating, and on the evaporator pipes, in the evaporator tank. And this leads to one of the possible faults.

As in all these cases, there are two possible sources of failure, leakage and obstruction. If the joints of the brine pipe leak, there is not the same quantity of brine circulating, and therefore there is not the same quantity of heat carried off. This trouble is very easily located, and the marine engineer can be trusted to grapple with it without difficulty. But the other possible source of trouble, the obstruction, is very much more serious, very much more difficult to discover, and very much more difficult to put right. The same rule applies in this case that has been given in connection with the compressor, and so on, "watch the gages." In this case the gages are the thermometers. When everything is working properly there will be a certain difference of temperature between the ingoing brine and the outgoing brine, from any given cold chamber. If there is an alteration in these quantities, if the incoming brine is at a higher temperature than it should be to produce the proper extraction of heat, the fault is to be found probably in the evaporator tank. The heat is not being properly extracted from the returning brine, and therefore it is not setting out at the low temperature it should have. The evaporator coils may not be doing their work properly, as described in the previous notes, or again, there may be a deposit on the inside of the brine pipes, which is preventing the heat from being extracted from the brine, as mentioned several times above.

Another possible cause of trouble with brine circulation arises when the brine is not sufficiently strong to withstand the low temperature of the evaporator tank. It will be understood that this is the other side of the question. As explained, the solution must not be too strong, for the reasons named. It also must not be so weak that in passing through any part of the system, say the evaporator coils, even a small portion of it will freeze. When this happens there is a formation of ice upon the outside of the evaporator coils, and this ice has the same effect, to a certain extent, in preventing the passage of heat from the brine to the refrigerant, as the deposit of the salt would.

The methods adopted where brine circulation is employed, with frozen produce, and with chilled produce, are sometimes quite different. It is evident that with frozen produce, all that is necessary being to maintain the temperature below a certain figure during the whole twenty-four hours, if a store of cold is provided in the hold or cold chamber, in the shape of a quantity of brine whose temperature is reduced to a certain figure, the plant may be worked for only a certain number of hours a day, the store being maintained at its temperature for the remainder of the time by drawing upon the reserve of cold in the brine store. This plan has a great deal to recommend it, and is often employed on shore. It has one obvious advantage, in that it allows of a smaller staff being employed. One "freezer" engineer, and perhaps a greaser, can run the plant for, say, a couple of watches during the day, get the brine to its temperature, and allow it to look after itself, with an occasional look at the thermometers, for the remainder of the twenty-four hours. The only thing necessary, and it involves only a very simple calculation, is that there shall be a sufficient quantity of brine, held at a sufficiently low temperature, to provide the necessary cold for the sixteen or eighteen hours during which the plant is not working. From the figures given for the specific heat of the brine solution, the

above calculation is easily made for a given size of hold or cold chamber, with a given quantity of produce stored in it.

With chilled meat, fruit, or produce which must not be frozen, and the temperature of which must not vary more than a very few degrees, it is necessary to run the plant continuously during the whole twenty-four hours; and further, the rise of temperature in the brine supplying the hold in which the chilled beef or fruit is held should be allowed to be only a very few degrees between the inlet and outlet. Again, the temperatures on the inlet and outlet pipe of each hold and of each portion of each hold, will be a guide to the "freezer" engineer, as to what is going on inside the hold, or that portion of the hold. If the temperature on the outlet is higher than proper working shows is best, evidently more heat from some cause is being given off inside, and it would probably be wise to deliver a larger quantity of the brine to that hold or that portion of the hold. On the other hand, if the temperature at the outlet is lower than the normal, it shows that there is very little difference in temperature between the brine and the air in that portion of the hold, and as this may mean that the temperature there is lower, or may become lower than it should be, the quantity of brine passing is lessened. This is done, of course, by means of the circulating pumps, and by the valves on the pipes and headers.

It will be wise, in the case of chilled meat and fruit, to check the indications of the thermometers in the brine, by thermometers in the stores themselves, and, for this purpose, thermometers arranged to indicate the temperature inside on some apparatus outside are of great service. There are several forms of electrical apparatus on the market which will accomplish this. In particular, there is a series of instruments made by the Cambridge Scientific Instrument Company, of Cambridge, England, and, the writer believes also, by firms in America, in which the variation in the resistance of a platinum wire is made to show the temperature tale inside of a cold store, at an indicating or testing board, on the outside in the engineer's room, or in any other convenient position.

The *rationale* of the arrangement is, the electrical resistance of all metals increases with a rise in temperature, and decreases with a fall in temperature, in a certain definite proportion, for each degree of rise or fall. If, therefore, an electric circuit is formed, including a small piece of platinum wire, a source of current and an electrical indicating apparatus (it may be a galvanometer, calibrated in degrees F. or C., the platinum wires being fixed upon the tubes arranged to be placed in the cold store, and the connecting wires being led through insulated tubes in the walls of the store to the indicating apparatus), every rise and fall of temperature will be seen at the indicating point, and may also be recorded upon a chart, in a manner similar to barometric and other records.

There are other arrangements worked electrically, in which a rise of temperature of a certain number of degrees closes an electric circuit and drops an indicator in the engineer's room; a fall of temperature of a certain number of degrees closing another circuit, and dropping another indicator, and so on. But the electrical thermometer, giving its own records upon a dial or chart, is, in the writer's opinion, far preferable.

It has one disadvantage, especially for seagoing work—it is necessarily delicate; but it is perfectly possible to protect the platinum wire in such a manner that even the knocking about in a very heavy seaway will not easily damage it, and the sure indications the thermometers give are worth a great deal of trouble to obtain, where such important results follow, as in the case of a variation of temperature with chilled meat, fruit, etc. With such a set of thermometers, and a careful attendant constantly watching the thermometers on the brine pipes and in the cold stores, it should, in the writer's opinion, be perfectly practicable to carry chilled meat, fruit, etc., for long voyages, six weeks or more, providing that the other points that have been mentioned in connection with the operation of the plant are attended to.

PREPARING THE BRINE SOLUTION.

It is very important indeed that the brine solution should be carefully prepared. It is not sufficient to take a tub of water and throw some calcium chloride into it, and allow it to dissolve. A certain definite quantity of the calcium chloride should be dissolved, in a certain definite quantity of water, and the purest water, distilled if possible, should be employed. On no account should sea water be employed, either as a solvent for the calcium chloride, or to take its place. A brine is made from common salt which answers all the requirements of a brine solution, if made in the proper strength, according to the temperature to which it has to be subject; but it is not wise to employ a salt brine solution, if calcium chloride can be obtained.

The reason is one that will be very familiar to marine engineers. Common salt acts chemically upon almost every metal with which it comes in contact, and particularly upon iron, while calcium chloride has practically no action upon iron, as long as it is pure. Where calcium chloride is employed, it is much better to use plain iron pipes than galvanized iron. Calcium chloride acts chemically upon zinc, with a liberation of hydrogen, and sometimes consequent troubles.

If the engineer is obliged to employ any salt for his solution, owing to his being in a port where calcium chloride is unobtainable, the following are the figures he has to work to: With 1 percent of common salt the freezing point of the solution is 30½ degrees F.; with 5 percent it is 25 degrees F.; with 10 percent it is 18 degrees F.; with 20 percent it is 6 degrees F.; and with 25 percent 5 degrees F. It will be seen that the freezing points are a little under those of the solution of calcium chloride. The specific heats are as follows: With 1 percent, 0.992; with 5 percent, 0.960; with 10 percent, 0.892; with 20 percent, 0.829; and with 25 percent, 0.783, about. There is very little difference again between the specific heats, though calcium chloride has slightly the advantage. If common salt is employed temporarily, as a brine solution, it should be made only with pure distilled water, or if distilled water is not obtainable, the purest water that can be had. Fresh water in any case, and the earliest possible return to the use of calcium chloride, should be made, the brine pipes being thoroughly washed out before the calcium chloride is admitted into them.

In preparing either the calcium chloride or the common salt solution, the best plan is to hold the salt either in a bucket with perforations, or in a cage, or something similar, weighing the proper quantity of the salt for a definite quantity of solution into the bucket or cage, and then either immersing the whole in a vessel containing the definite quantity of water to make the proper density of solution, or pumping the water in over the cage into a vessel arranged to hold it, and allowing the whole to settle, etc.

There is another point which ought to be mentioned. Commercial calcium chloride too often contains impurities, even as much as 25 percent of common salt, and if a solution is made up from this substance, chemical actions will take place between the calcium chloride and the common salt, leading to a reduction in the efficiency of the system. That is to say, a definite quantity of a given solution, passing through a cold chamber in a given time, the liquid having been cooled to a given temperature, will not absorb the same quantity of heat as the pure solution of calcium chloride or sodium chloride would have done. In addition to this, in working, the sodium chloride, being less soluble than the calcium chloride, is apt to somewhat freely deposit on the inside of the pipes, with the results that have been mentioned. When buying calcium chloride, therefore, it is wise to test it, and the best test is, by making a small quantity of solution, of a definite density, and taking its freezing point. That is to say, freezing it, as can easily be done where there is a refrigerating plant on the ground, and taking the freezing point with a thermometer.

Calcium chloride and sodium chloride are very much alike in appearance, and, in addition, commercial calcium chloride contains, on an average, 25 percent of water, and will absorb from half to nearly all its own weight of water when the conditions are favorable. In America the calcium chloride, in its commercial form, comes from the makers in a solid cake inclosed in air-tight thin iron drums. Before use, it has to be broken up into lumps, the lumps being put into the cage or bucket, as explained.

(To be concluded.)

The First English Motor Cargo Boat.

BY FRANK C. PERKINS.

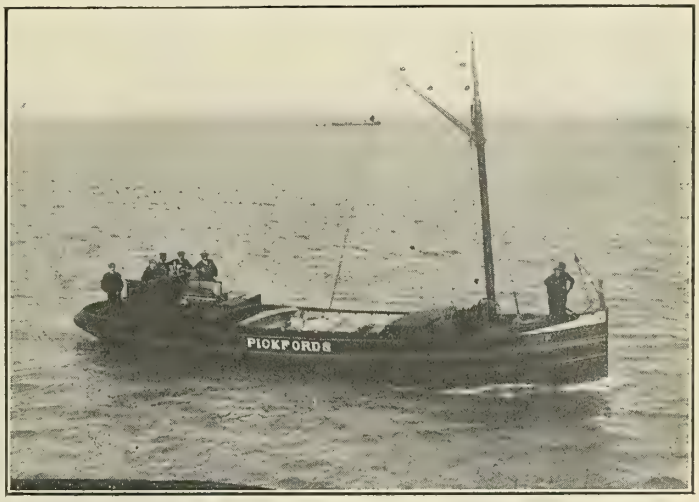
The sea-going motor barge Pickford's *Wasp* is said to be the first English motor cargo boat, and it is of particular interest on this account, as it shows how the paraffin and gasoline engine has entered the field, not only of handling freight on land by means of the motor truck, but also for future use to a considerable extent at least on lakes and rivers for similar purposes. This English single screw barge is fitted with a 26-horsepower Kromhout motor, constructed by Messrs. Pickford, Ltd., and designed by D. Goedkoop, Jr., of the Kromhout Motor Works, of Amsterdam, Holland. It is a single cylinder engine with crank revolving in an inclosed oil retaining case. The ignition is electric low tension, with oscillating magneto driven from the same shaft as the exhaust valve, with make and break contact moved from the oscillating lever of the magneto apparatus.

The fuel is Russian petroleum, the density varying between 0.820 and 0.840, the average flash point being 83 to 84 degrees, Abel's close test. While the above specific gravity and flash point are recommended, the motor will run on more refined oils or cruder oils with very good satisfaction. It is stated that two Kromhout tugs supplied with Borneo oil are working successfully in Asia, the density being 0.850, and the flash point 73 degrees, in this case, by Abel's close test. It is stated that the starting charge can be of any density from 0.680 to 0.720, while the ordinary motor spirit or gasoline necessary for starting can readily be obtained in almost all parts of the world.

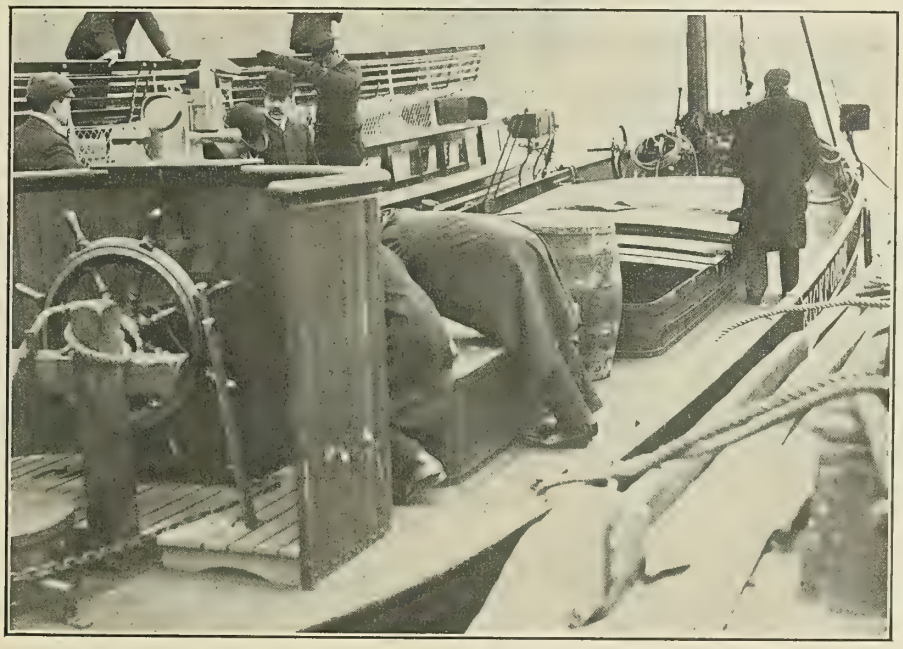
The *Wasp* is 55 feet 6 inches long and 12 feet 3½ inches beam, with a draft when loaded of 3 feet 6 inches. She has a capacity of 20 tons deadweight, and 33 tons cubic measurement on 3½ feet draft. She has a speed of 7¼ knots, and is provided with a motor winch capable of lifting a half ton, and located in the engine room.

This barge is built of mild steel, the peak being about 2 feet 8 inches long, taken at anchor chain. The propeller frame is 3 by 1 inch and the stern frame 3 by 1 inch, while the rudder head is 2½ inches and the rudder plate ⅜-inch (single), the outside plating being ¼-inch and the frame spacing 16 inches. The frames are 2 by 2 by ¼-inch, and the floors 6 by ¼-inch, while the deck is 3/16-inch and the ceiling 1½ inches. The beams are 3 by 2 by ¼-inch, and those along the side hatch 2 by 2 by ¼-inch. This data is given in detail, as steel boats of this type are not extensively used with internal combustion engines.

The mast and derrick are of pine, and the steering wheel of teakwood, brass mounted, is so placed that the helmsman can handle the boat and engine from a strong shelter arranged around the wheel. Aft of the engine room is a space to be used for stores.



THE MOTOR CARGO BOAT PICKFORD'S WASP.



DECK VIEW OF THE NEW MOTOR PROPELLED CARGO BOAT PICKFORD'S WASP.

We trust that Vickers, Sons & Maxim, Ltd., have no grudge against us for having on page 462 of our December number inadvertently transferred their works from Barrow-in-Furness to Elswick.

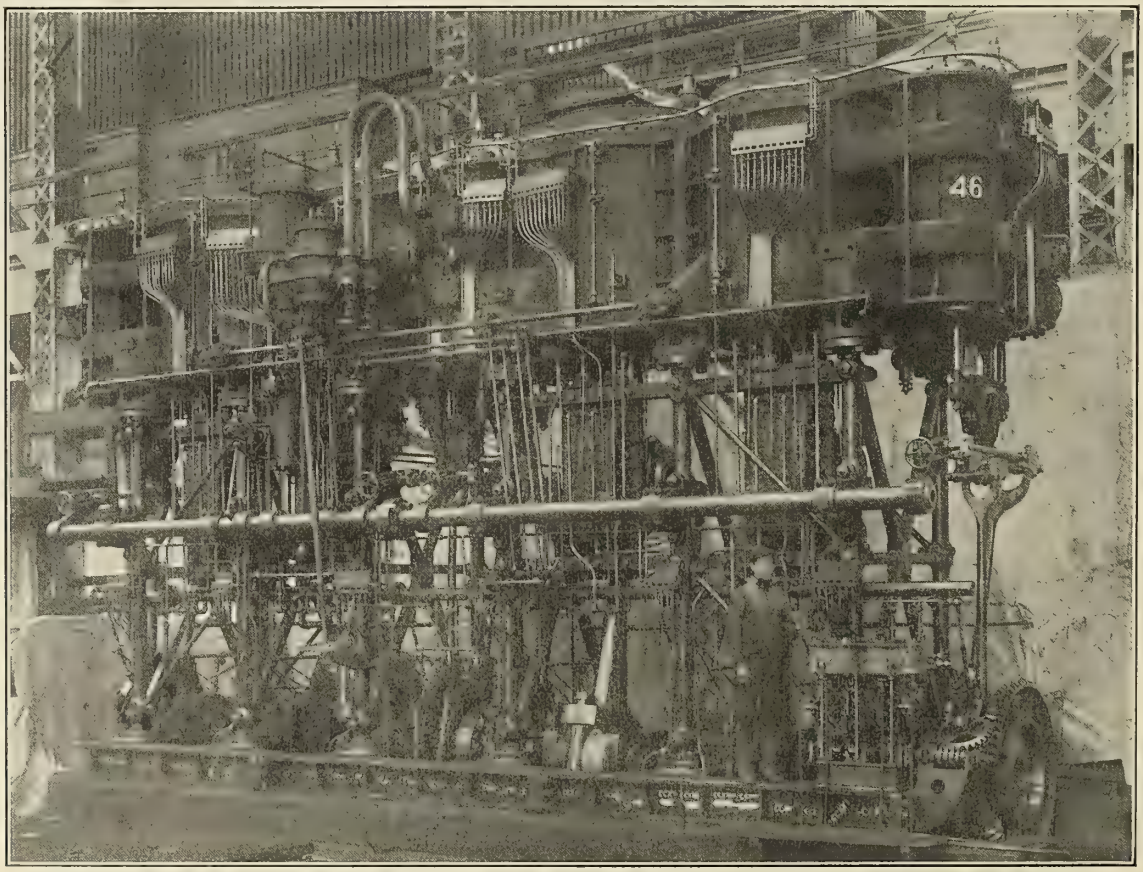
CONTRACT TRIAL PERFORMANCE OF THE UNITED STATES BATTLESHIP MINNESOTA.

BY A. F. BOWEN AND H. B. GREGORY.

GENERAL DESCRIPTION.

The *Minnesota** (Battleship No. 22), built by the Newport News Shipbuilding & Dry Dock Company, Newport News, Virginia, is one of the twin-screw battleships of the *Vermont* class, authorized by Congress in an act approved March 3, 1903. The contract for the *Minnesota,* signed June 20, 1903, provided for the delivery of the completed vessel within forty-two months from that date; that is, on or before December 20, 1906. The keel was laid October 27, 1903, and the vessel launched April 8, 1905. The contract price for the vessel, exclusive of armor, armament, etc., which are supplied by the government, is $4,110,000, of which $3,110,000 was allotted for the hull, and $1,000,000 for the machinery.

Breadth, molded	76 feet 5½ inches
Breadth, extreme	76 feet 10 inches
Ratio length to beam	5.856
Depth molded to main deck side at midship section.	43 feet 1⅜ inches
Draft	24 feet 6 inches
Displacement, normal—24 ft. 6 in. draft	15,970 tons
Displacement, per inch—24 ft. 6 in. draft	63.2 tons
Area of immersed midship section	1,808 square feet
Area of the load water plane	26,560 square feet
Area of wetted surface at normal draft	44,500 square feet
Center of gravity of L.W.L. plane aft of M.S.	4.4 feet
Center of buoyancy above bottom of keel	13 feet 4 inches
Center of buoyancy aft of M. S.	0.765 feet
Transverse metacenter above center of buoyancy	18 feet 9½ inches
Longit'nal metacenter above center of buoyancy.	538 feet 6 inches



THE STARBOARD ENGINE OF THE BATTLESHIP MINNESOTA, LOOKING FORWARD, AS ERECTED IN BUILDERS' SHOP.

The guaranteed speed of the *Minnesota* was 18 knots, to be maintained for four consecutive hours, on a mean draft of 24 feet 6 inches, corresponding to a displacement of about 15,970 tons. The designed power to produce this speed was about 16,500 collective indicated horsepower of propelling machinery, at about 120 revolutions per minute of the main engines; this to be attained at an average air pressure in the fire rooms of not more than 2 inches, with a maximum air pressure of 2¼ inches. And it was further stipulated, that the vessel should be subject to an endurance trial, under all boilers, of twenty-four hours consecutive duration in the open sea, at an average of not less than 13,200 indicated horsepower. A standardization run was also required by the department.

HULL DIMENSIONS.

Length between perpendiculars (also L.W.L.)	450 feet 0 inches
Length over all	456 feet 4 inches
Projection of ram forward of F. P.	6 feet 4 inches

Coefficient of fineness—block	0.6592
Coefficient of fineness—midship section	0.9604
Coefficient of fineness—L.W.L. plane	0.7683
Coefficient of fineness—cylindrical	0.6963
Number of frames (spaced 4 feet throughout).	112
Number of watertight compartments	314

In general, the particulars of arrangements and outfit are the same as those of the *Louisiana;** but the following items may be mentioned:

The hawse pipes enter the main deck, and the anchor chains lead to the windlass house, which projects through the deck. Bill boards and cranes for each of the sheet anchors, Navy type, are on this deck. The Baldt type of anchor is used for the bowers, and is stowed in the hawse pipes. The wireless telegraph station is also located on this deck, in the after part of the superstructure.

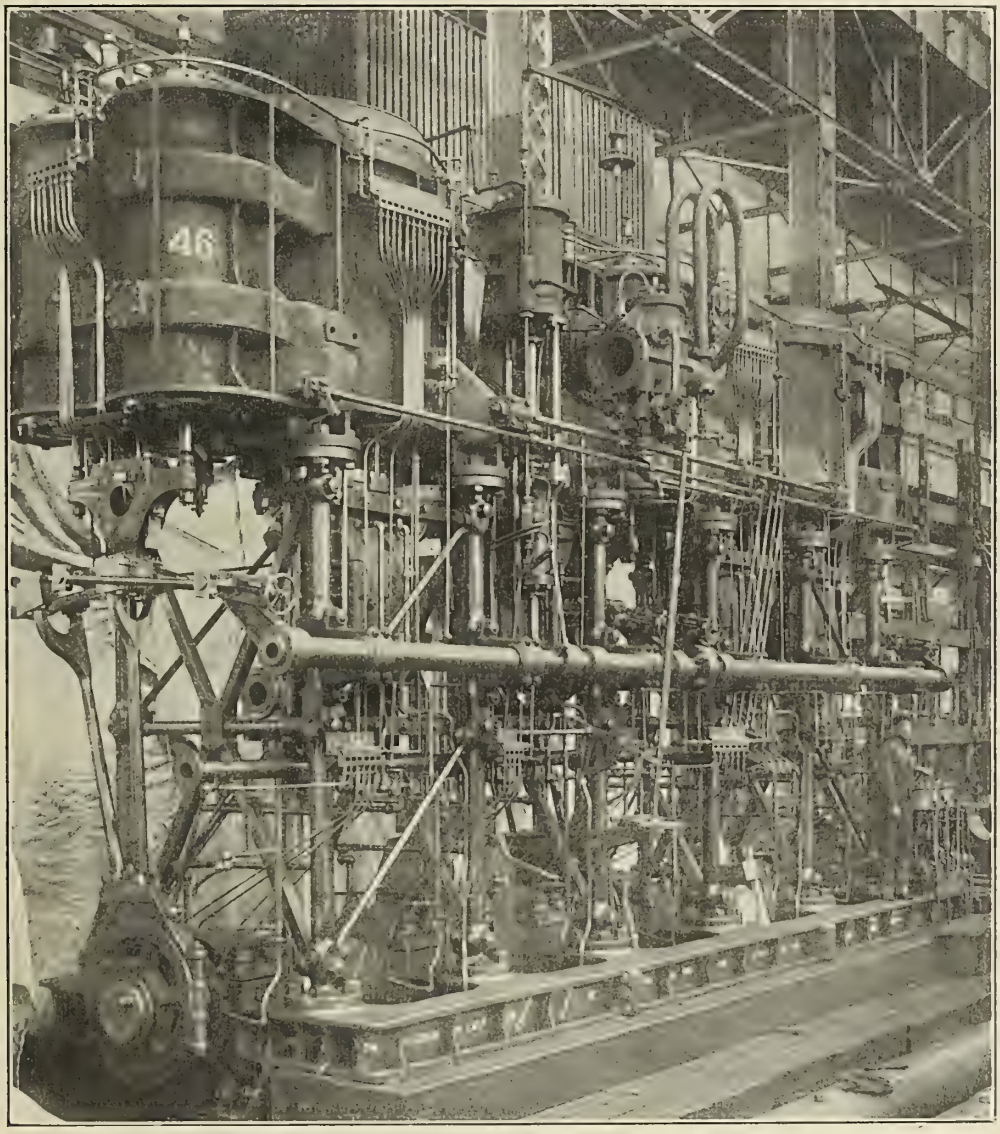
The protective deck extends the entire length of the ship, and is 3 inches thick on the slope and 1½ inches on the flat. The

*For dock trial, see page 468 of our issue for December, 1906. For launching, see page 251, June, 1905.

*See International Marine Engineering, May, 1906, pages 165 to 174, for complete data of trial and description of ship.

space between the protective and berth decks is utilized for stores, except abreast the fire rooms, where it is used for coal.

On the upper platforms are the magazines, handling rooms, store rooms, forward and after dynamo rooms, and steering engine room. The lower platform contains the forward and after torpedo rooms, magazines, and store rooms. In the hold are store rooms, magazines, chain lockers, coal bunkers, engine and boiler compartments and trimming tanks. There are thirty-four coal bunkers, twenty-four in the hold and ten on the protective deck, with a total capacity of 2,403 tons, at 43 cubic feet to the ton.



STARBOARD MAIN ENGINE OF UNITED STATES BATTLESHIP MINNESOTA, LOOKING AFT.

There is one Hyde Windlass Company steam windlass, capable of hoisting two anchors of approximately 17,600 pounds each, at a speed of 6 fathoms per minute. The windlass is driven by a double upright engine, with steam cylinders 17 inches in diameter, and 14 inches stroke, located on the gun deck, and connected to the windlass through a vertical shaft and a set of worm and bevel gears.

ARMOR.

A complete waterline belt, 9 feet 3 inches wide amidships, is fitted from stem to stern. In wake of the machinery the armor is 11 inches thick at top and 9 inches at the bottom. On the quarters, the armor is reduced to 9 inches at top and 7 inches at the bottom, then to 7 inches at top and 5 inches at bottom, then to 5 inches constant thickness, and finally to 4 inches constant thickness. Above the main belt, and covering the central portion of the hull, the ship's sides are protected by upper and lower casemate armor 6 inches and 7 inches thick respectively. Forward and aft on the main deck are the two 12-inch elliptical balanced turrets, turning over circular barbettes. The armor for these turrets is 12 inches thick on the port plates, and 8 inches thick on the sides and back. There are also four 8-inch elliptical balanced turrets, having port plates 6½ inches thick, with back and sides 6 inches.

ORDNANCE.

Main battery: four 12-inch breech-loading rifles; eight 8-inch breech-loading rifles; twelve 7-inch rapid-fire rifles.

Secondary battery: twenty 3-inch 50-caliber rapid-fire rifles; ten 3-pounder semi-automatic Hotchkiss rapid-fire rifles; two 1-pounder automatic guns; two .30-caliber machine guns. The ship has also four 21-inch submerged torpedo tubes, two forward and two aft, with complete outfit of compressors, accumulators, etc.

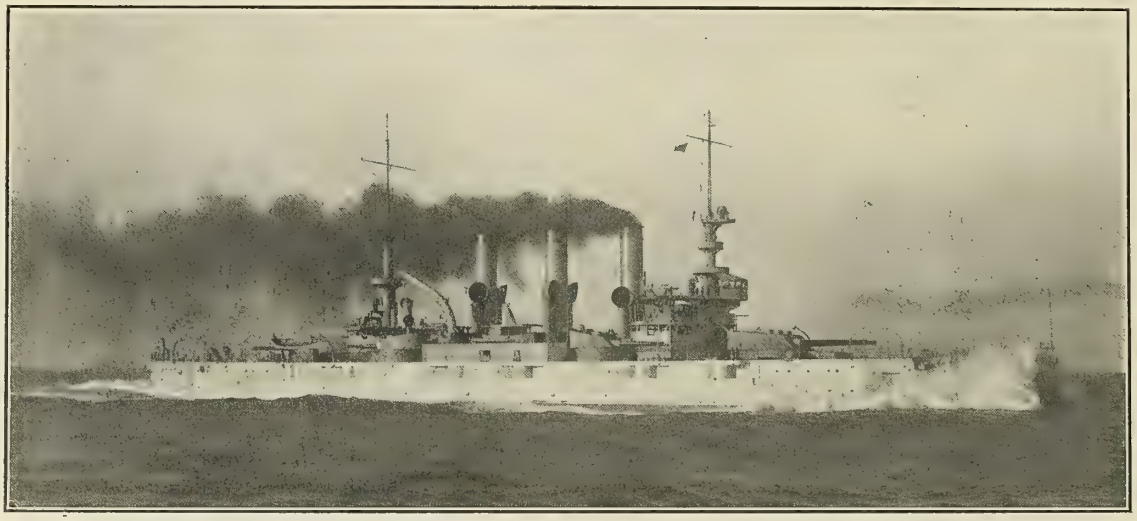
PROPELLING MACHINERY.

There are two main engines, of the four-cylinder, vertical, inverted, direct-acting, triple expansion type, placed abreast in two separate watertight compartments, with communicating watertight door in the center line bulkhead at the working platform. The order of the cylinders, beginning forward, is: forward L. P., H. P., I. P., and after L. P. The crank sequence is: H. P., I. P., F. L. P., and A. L. P., all crank angles being ninety degrees. The engines are right and left, and turn outboard when

going ahead. The designed indicated horsepower of the main engines was 16,500 at about 120 revolutions per minute, with a steam pressure of 250 pounds at the high-pressure steam chest.

The H. P. and F. L. P. cylinders and the I. P. and A. L. P. cylinders are securely bolted together, but there is no rigid fastening between the two cylinder pairs thus formed, which are guided together to prevent athwartship motion, but allowing fore-and-aft play for expansion.

The cylinders are supported on twelve forged steel cylindrical columns, tied fore and aft by heavy cast steel horizontal I-braces and forged steel horizontal and diagonal rods, and strengthened athwartships by forged steel X-frames, extending from top to bottom of the columns, and horizontal tie rods at the center of the columns and X-frames. The engines are also stiffened by fore-and-aft and athwartship tie rods between the cylinders of opposite engines, and between the forward and after engine room bulkheads and the engine cylinders.



THE UNITED STATES BATTLESHIP MINNESOTA STEAMING AT 18.74 KNOTS ON STANDARDIZATION RUN NO. 2.
(Copyrighted, 1906, N. L. Stebbins.)

The main valves are of the single ported piston type. They are built up with top and bottom cast steel heads, and a steel distance piece between the heads. Each head is fitted with a single cast iron packing ring and cast steel follower. The H. P. cylinders have one valve and the I. P. and L. P. cylinders two valves each. A balance piston, fitted at the top of each valve stem and working in a small cylinder in the top of the valve chest cover, is provided to relieve a part of the weight of the valve gear, which is of the double bar Stephenson link and sliding block type. The H. P. valve stem connects direct to its link block, while the two stems of each I. P. and L. P. cylinder are secured to a cross-head, which in turn is connected to the link block.

The main engines are duplicates of those of the *Louisiana*.

Cylinders, H. P., diameter, inches	32½
I. P., diameter, inches	53
L. P. (2), diameter, inches	61
Stroke of all pistons, inches	48
Piston valves, H. P. (1 each cylinder), diameter, inches	17½
I. P. (2 each cylinder), diameter, inches	19
L. P. (2 each cylinder), diameter, inches	19
Net area of I. P. to H. P. piston, ratio	2.659 to 1
Net area of L. P. pistons (2) to H. P. piston, ratio	7.046 to 1
Connecting rods, length center to center, inches	96
Crank shaft, diameter, inches	16½
Crank pin, diameter, inches	17½
Crank webs, width, inches	19
thickness, inches	10¼
Thrust shaft, diameter, inches	15½
collars, number in each shaft	13
Line shafts, diameter, inches	15½
Stern tube shafts, diameter, inches	16½
Propeller shafts, diameter, inches	16½

The auxiliary machinery is, in general, the same as that of the *Louisiana*. It may be noted, however, that the thickness of the tubes of the two main condensers is of No. 16 B. W. G., or 0.065 inch, instead of No. 18 B. W. G., or 0.049 inch. The same may be said with regard to the four auxiliary condensers.

All the living spaces are heated by steam radiators. The heating system is divided into thirteen independently controlled circuits (including galley, pantry, and wash room circuits). Each radiator is also independently controlled. In this way any circuit or radiator may be shut off without interfering with the balance of the system. Steam is supplied from the auxiliary steam line, reducing valves being fitted at all connections.

A pneumatic plant is provided for the purpose of operating pneumatic tools and cleaning boilers. It consists of an air compressor and accessories located in the forward end of the port engine room. An air main is led through the engine and fire rooms, with branches to workshop and evaporator room, all fitted at suitable intervals with connections for attaching flexible hose for pneumatic tools, etc.

SCREW PROPELLERS.

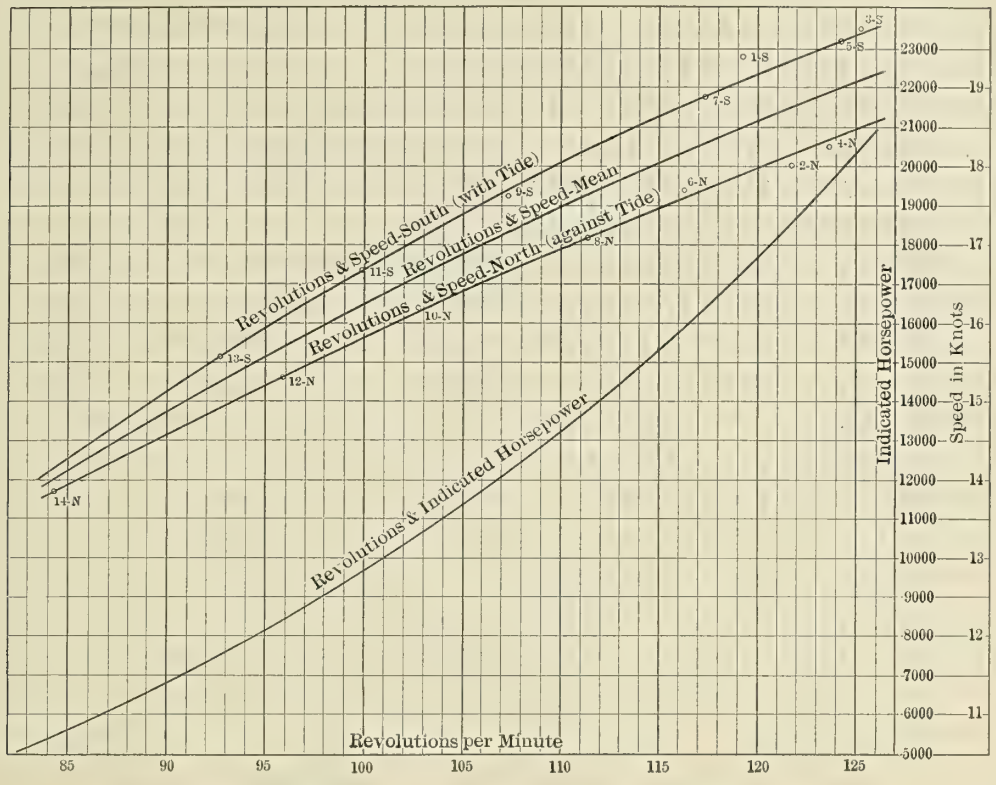
The two built-up propellers are of manganese bronze, turning outboard when going ahead. They have three blades and are designed as true screws.

Diameter of propeller	17.365 feet
Diameter of hub	4.375 feet
Pitch, as set	18.07 feet
Pitch, ratio to diameter	1.0405
Pitch, adjustable between	17 and 19 feet
Helicoidal (developed) area, square feet	85.735
Projected area, square feet	72.78
Disk area, square feet	236.85
Ratio, projected area to disk area	0.307

BOILERS.

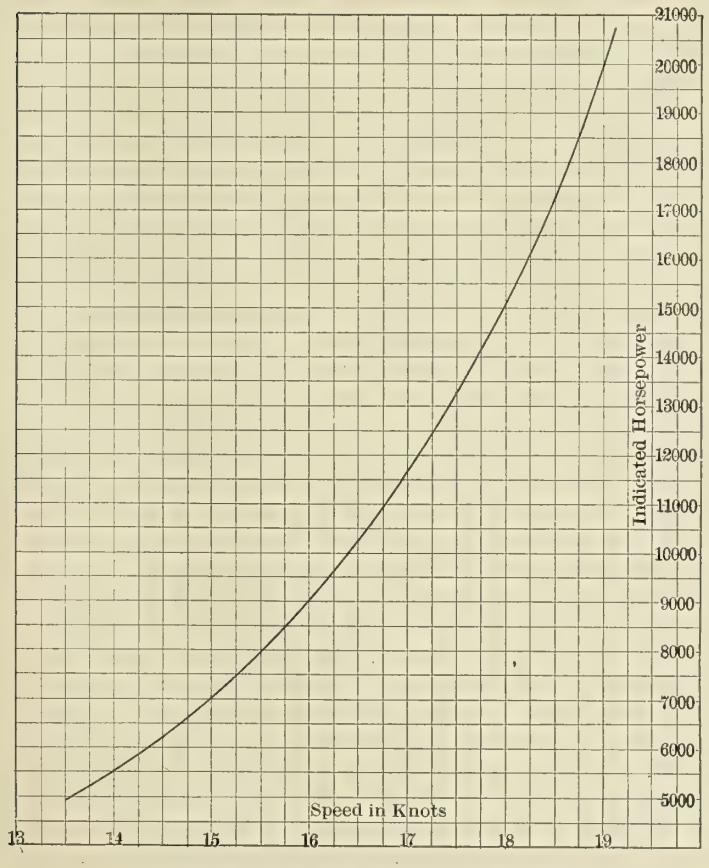
Steam is supplied by twelve Babcock and Wilcox watertube boilers designed for a working pressure of 265 pounds per square inch, and arranged, two each, in six communicating watertight compartments, with athwartship fire rooms between each two boilers. There are three smoke pipes, 8 feet 3 inches internal diameter and 92 feet 5 inches above the grates. Four boilers connect to each smoke pipe.

Grates, length	7 feet 0 inches
width	6 feet 6.576 inches
Grate surface, square feet	91.67
all boilers, square feet	1,100.00



CURVES PLOTTED FROM RESULTS OF STANDARDIZATION RUNS OF BATTLESHIP MINNESOTA.

Heating surface, square feet	4,396.
all boilers, square feet	52,752.
Heating surface, ÷ grate surface	47.96
Grate surface ÷ cross section smoke pipe	6.859



SPEED-POWER CURVE FROM STANDARDIZATION RUNS.

OFFICIAL PRELIMINARY TRIALS.

The standardization method of trial was decided upon, and the government measured mile course off Rockland, Maine, was selected for the trial. The *Minnesota* sailed from Newport News on Saturday morning, October 20, 1906. On the run up the coast a forced draft run of about an hour and a half duration was indulged in, to satisfy the engineers that everything was in prime condition for the trials. Rough sea and occasional thick weather were encountered, and Rockland was not reached until a little after noon, Monday, October 22.

As previously noted, this vessel was required to stand three distinct trials, as follows: first, the standardization run, for the purpose of establishing the revolutions and corresponding speeds; second, the four-hour full power run, to demonstrate the ability to maintain the contract speed for four consecutive hours; third and lastly, the twenty-four endurance run, at four-fifths of full power. The latter requirement is a new feature, this being the first vessel for the United States navy to be subjected to it.

The standardization trial was run on October 24. The morning broke fine and clear, and the sea was smooth. Fourteen successful progressive runs were made over the course, the data obtained being shown in the table. The curves are plotted from this data. The results showed 114.5 revolutions per minute of the main engines to be necessary to make the contract speed of 18 knots.

FOUR-HOUR TRIAL.

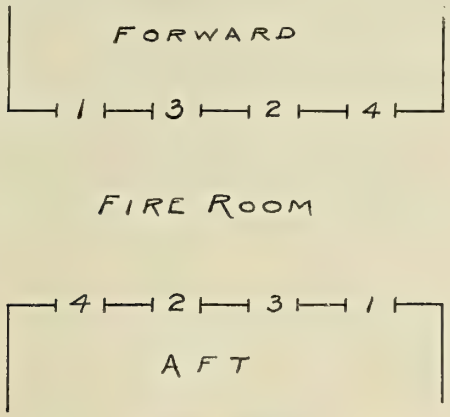
On October 25, the four-hour trial was run at sea, between Rockland and Boston. Thick weather, rough sea and a head wind were encountered, but an average speed of 18.851 knots was maintained for the four consecutive hours, thus exceeding the contract speed by 0.851 knot. The machinery plant worked admirably throughout the entire run. The coal used was hand-picked, put up in bags of 112 pounds each (20 bags to the ton) and an accurate record of the bags of coal burned during the four hours was kept, for the purpose of arriving at the coal consumption.

The firing of the furnaces was controlled by an electric signal, automatically operated by a small motor. The furnace doors

U. S. S. MINNESOTA. DATA FROM STANDARDIZATION TRIAL ON MEASURED MILE OFF ROCKLAND, MAINE, WEDNESDAY, OCTOBER 24, 1906.

Number and Direction of Run.	Time on Course. Min. Sec.	Which Engine.	Revolutions of Main Engines. For one Nautical Mile.	Revolutions of Main Engines. Per minute.	Revolutions of Main Engines. Average.	Speed in Knots.	Steam Pressures. Gage. In Boilers.	Steam Pressures. Gage. At Engines.	Steam Pressures. Gage. H. P. Steam Chest.	Steam Pressures. Absolute. 1st Rec'r.	Steam Pressures. Absolute. 2nd Rec'r.	Mean Effective Pressures. H. P. Cyl.	Mean Effective Pressures. I. P. Cyl.	Mean Effective Pressures. F. L. P. Cyl.	Mean Effective Pressures. A. L. P. Cyl.	Mean Effective Pressures. Referred to L. P. Cyls.	Vacuum in Inches.	Air Pressure in Inches of Water.	Indicated Horsepower. Main Engines. H. P. Cyl.	I. P. Cyl.	F. L. P. Cyl.	A. L. P Cyl.	Total.	Total Both Engines.	Auxiliaries in Operation.	Total All Machinery.	Cut-off in Cylinders. H. P.	I. P.	F. L. P.	A. L. P.
1-S	3- 5.45	S	366.	118.32	119.20	19.412	245.3	235	220	105	34	108	47.5	19	19.5	52.24	26.2	1.67	2514	2979	1582	1624	8699	17581.1	1003.3	18584.4	.837	.726	.687	.687
		P	371.4	124.07				235	223	108	36	103.2	48.7	19.5	20.2	52.5	25.3		2430.5	3097.7	1647.2	1706.7	8882.1				.828	"	"	"
2-N	3-20.	S	403.	120.90	121.80	18.000	271.5	235	230	97.5	36	107	47	17.6	19	51	25.2	1.93	2545	3012	1498	1617	8672	18111.9	1033.6	19145.5	.852	"	"	"
		P	408.95	122.69				245	242	113	38.5	109	50	20.4	20.9	54.79	25.2		2623.6	3250.4	1761.2	1804.7	9439.9				.828	"	"	"
3-S	3- 2.5	S	378.2	124.58	125.21	19.726	277.5	255	250	125	39.5	107.5	55.5	21	21.5	57.15	26.2	1.45	2635	3665	1841	1886	10027	20318.6	917.3	21235.9	.852	"	"	"
		P	382.	125.84				255	247	130	42.5	106	54.8	21.9	23.5	58.19	25.2		2617	3654	1939.2	2081.4	10291 6				.852	"	"	"
4-N	3-17.25	S	404.45	123.37	123.71	18.251	272.9	247.5	245	110	40	105	56.3	21.5	22.5	57.9	26.4	1.03	2549	3681	1866	1954	10050	19827.5	794.1	20621.6	.852	"	"	"
		P	406.65	124.04				250	237	120	39.8	108	53	20	22	56.45	25.6		2628	3483.4	1745.7	1920.4	9777.5				.852	"	"	"
5-S	3- 3.8	S	380.55	124.23	124.30	19.587	275.0	249	247	122.5	40	104	54.5	21.5	22.5	56.9	26.5	.92	2542	3575	1862	1969	9948	19988	795	20783	.852	"	"	"
		P	381.	124.37				253	245	122	40.1	109.6	54	21.3	22.2	57.49	25.7		2674.2	3558.5	1864.1	1943.2	10c40				.792	"	"	"
6-N	3-23.4	S	391.95	115.76	116.27	17.699	234.7	207.5	205	99	32.5	91	44.5	17.5	17.3	46.9	26.9	.51	2073	2730	1426	1409	7638	15694.9	602.7	16297.6	.837	"	"	"
		P	395.4	116.78				213	210	98	32.2	103	44.8	17.3	18.3	49.13	25.8		2359.6	2771.9	1421.4	1504	8056.9				.816	"	"	"
7-S	3-10.45	S	372.25	117.28	117.32	18.903	265.5	250	230	96	32.5	107.5	45	17.8	18	49.9	26.9	.71	2481	2797	1469	1486	8233	16460.5	654.3	17114.8	.807	"	"	"
		P	372.6	117.36				250	225	97	32.5	110	43.9	17.6	18.3	49.86	25.9		2532.6	2729.9	1453.4	1511.6	8227.5				.792	"	"	"
8-N	3-30.83	S	391.85	111.64	111.34	17.075	259.0	235	215	82.5	28	105	38	15.1	15.8	44.4	27.0	.52	2306	2249	1186	1242	6983	13710.9	564.4	14275.3	.762	"	"	"
		P	389.75	111.04				240	215	78	28	110.2	35.3	14	14.8	43.1	25.9		2400.6	2076.8	1093.9	1556.6	6727.9				.744	"	"	"
9-S	3-23.95	S	365.1	107.23	107.39	17.651	256.8	250	230	71	23.5	112	31.5	12.4	12.9	40.1	27.4	.21	2363	1790	936	974	6063	12148.5	465.7	12614.2	.657	"	"	"
		P	366.25	107.56				250	230	57	24.2	114	31.5	12.4	12.5	40.25	25.8		2405.5	1795.2	938.5	946.3	6085.5				.731	"	"	"
10-N	3-42.63	S	380.15	102.56	102.81	16.170	259.0	250	230	61	21.5	108	29.7	11.1	11.8	37.8	27.2	.12	2179	1615	801	852	5447	10841.6	423.7	11265.3	.610	"	"	"
		P	382.	103.06				250	215	57	22	107.6	28.8	11.3	11.4	37.24	26.2		2175.5	1572.7	819.5	826.9	5394.6				.731	"	"	"
11-S	3-35.6	S	359.35	99.99	99.97	16.698	263.5	255	255	57	19.5	102	25.5	10.1	10.6	34.3	27.5	0	2007	1351	711	746	4815	9718	417.1	10135.1	.610	"	"	"
		P	359.15	99.95				255	202	57	20.5	101	26.5	10.7	10.9	34.96	26.6		1980.4	1403.4	752.5	766.7	4903				.731	"	"	"
12-N	3-55.3	S	376.45	96.12	95.87	15.299	260.2	255	185	52.5	18	94.5	22.7	9.3	9.6	31.2	27.6	0	1787	1157	629	650	4223	8386.4	394.6	8781	.610	"	"	"
		P	374.45	95.61				254	183	52	18.5	89.8	23.3	9.7	9.6	30.99	26.9		1684.4	1180.4	652.6	646	4163.4				.731	"	"	"
13-S	3-51.	S	355.95	92.48	92.78	15.584	252.1	248	175	47	16.5	83.5	22.2	8.7	8.9	28.8	27.6	0	1520	1088	566	679	3753	7486.6	395.9	7882.5	.610	"	"	"
		P	358.25	93.07				248	170	48	18.2	85	20.2	9.1	9	28.59	26.9		1552	996.1	596	589.5	3733.6				.731	"	"	"
14-N	4-20.2	S	364.35	84.08	84.30	13.836	246.8	244	125	35	13	61.5	17	6.8	6.3	21.5	27.6	0	1017	757	402	373	2549	5474	392.9	5866.9	.610	"	"	"
		P	366.25	84.52				243	142	42	16.5	73	18.1	7.5	7.7	24.68	27.0		1210.4	810.6	446	458	2925				.731	"	"	"

were numbered as per sketch. The signal interval was 30 seconds, the cycle of operations being as follows:



FIRING DIAGRAM.

1st bell, fire No. 1;
2d bell, rake No. 2;
3d bell, fire No. 3;
4th bell, rake No. 4;
5th bell, rake No. 1;
6th bell, fire No. 2;
7th bell, rake No. 3;
8th bell, fire No. 4.

Thus each furnace was fired every four minutes.

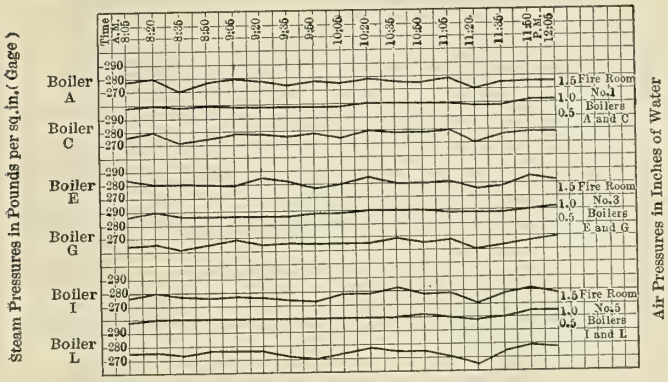

Steam Pressures in Pounds per sq. in. (Gage)
Air Pressures in Inches of Water
Boiler A
Boiler C
Boiler E
Boiler G
Boiler I
Boiler L
1.5 Fire Room No. 1 Boilers A and C
1.5 Fire Room No. 3 Boilers E and G
1.5 Fire Room No. 5 Boilers I and L

CHART FROM STARBOARD FIRE ROOMS, FOUR-HOUR TRIAL.

The following men were on watch during the trial:

Engine Rooms: 1 chief engineer, 6 assistant engineers, 4 machinists, 26 oilers, 10 pump men, 2 store keepers; total, 49.

Fire Rooms: 1 chief engineer, 3 assistant engineers, 28 firemen, 30 coal passers, 6 water tenders, 6 blower men, 2 machinists; total, 76; grand total, 125. Two hundred and seventy-three men constituted the engineering force.

The tabulated comparative figures between the *Louisiana's* trial performance and that of this vessel may be of interest. Both these vessels are identical in every respect, save the direction of rotation of the propellers.

	Propellers Turn	To make 18 Knots		Data from Four-hour Trials					
		R. P. M.	I. H. P.	R. P. M.	I. H. P. Main Eng's	I. H. P. Total	Slip %	Kn'ts	Admiralty Constant
Louisiana.	Inboard	119.1	15,730	127.68	20,442	21,350	17.00	18.823	197.
Minnesota.	Outboard	114.5	15,140	122.93	19,896	20,572	14.01	18.851	201.5
Difference in favor *Minnesota*		4.6	590	4.75	546	778	2.99	0.028	4.5

The comparison indicates an advantage in outboard turning propellers for this design of vessel.

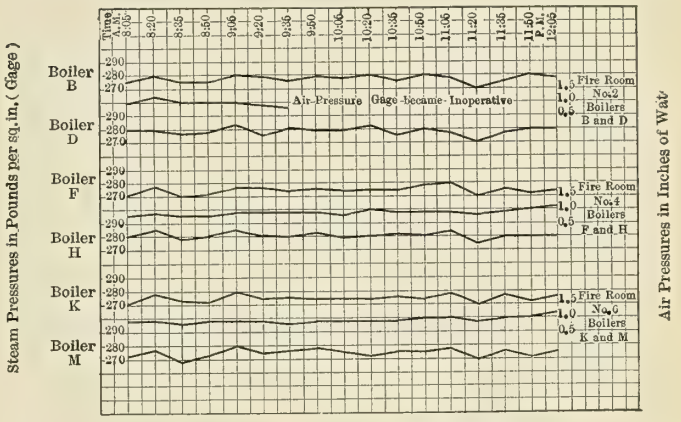

Steam Pressures in Pounds per sq. in. (Gage)
Air Pressures in Inches of Water
Boiler B
Boiler D
Boiler F
Boiler H
Boiler K
Boiler M
Air-Pressure Gage became Inoperative
1.5 Fire Room No. 2 Boilers B and D
1.5 Fire Room No. 4 Boilers F and H
1.5 Fire Room No. 6 Boilers K and M

CHART FROM PORT FIRE ROOMS, FOUR-HOUR TRIAL.

TWENTY-FOUR-HOUR ENDURANCE TRIAL.

This trial, which was commenced at 8.00 P.M. on the day of the four-hour trial, was at sea, between Boston and Newport News. Excellent weather was encountered and an average I. H. P. of 15,116 was developed, which exceeded the requirement (13,200 I. H. P.) by a good margin. The firing was controlled as on the four-hour trial, except that the interval

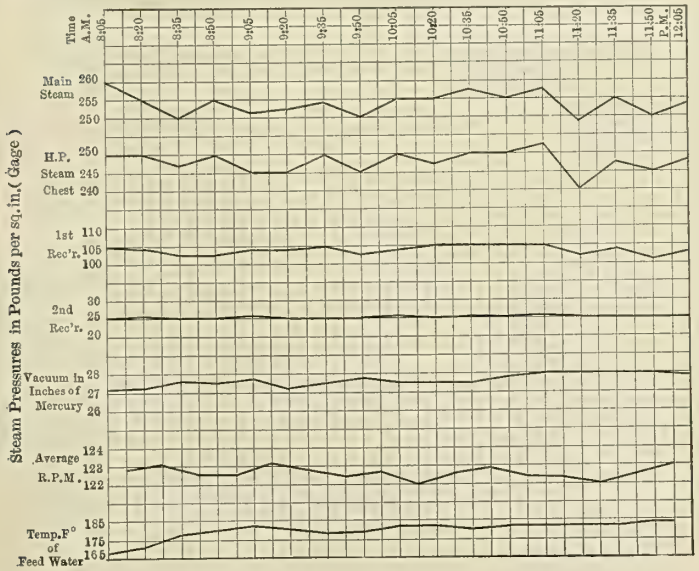


CHART FROM STARBOARD ENGINE ROOM, FOUR-HOUR TRIAL.

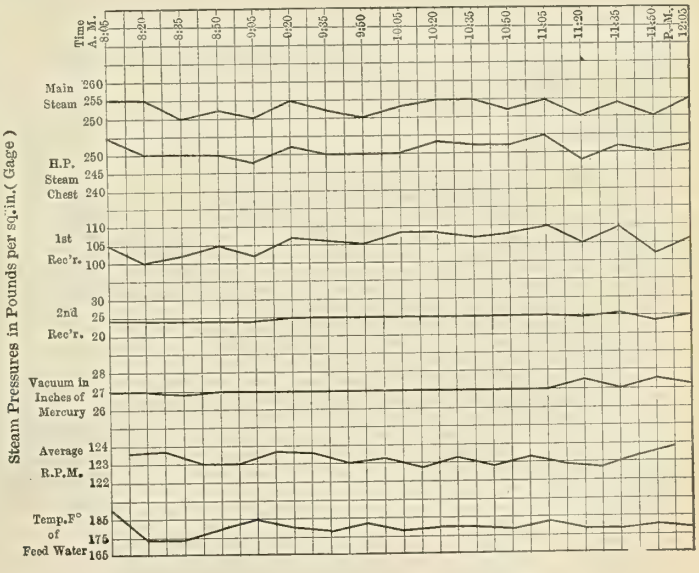
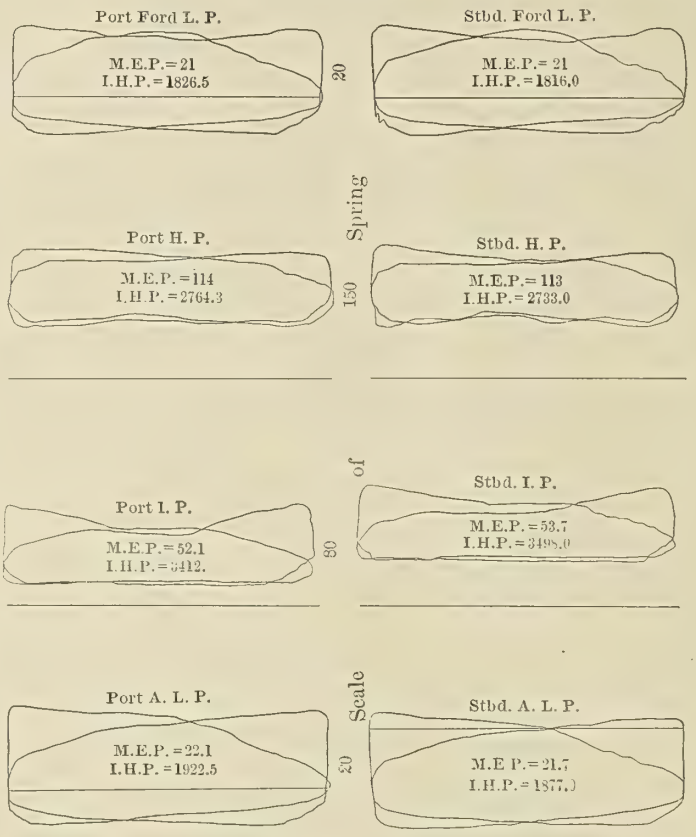


CHART FROM PORT ENGINE ROOM, FOUR-HOUR TRIAL.

SYNOPSIS OF TRIALS.

	Four-Hour		Twenty-Four Hour	
	Starb'd	Port	Starb'd	Port
Steam pressures:				
at boilers, gage	275.6		245.19	
engine room, gage	254	252.2	226.5	228.8
H. P. steam chest, gage	249	250.8	221	225.5
1st receiver, absolute	119	122.7	88.5	85.4
2d receiver, absolute	40.1	39.7	31	29.9
Vacuum in Condenser	26.2	26.24	26.2	26.2
Revolutions per minute:				
main engines	122.6	123.26	114.04	113.8
average for both	122.93		113.92	
circulating pumps	183	194	168.16	166.87
blower engines	349.2		349.4	
dynamo engine	352		339.21	
Double strokes per minute:				
main air pumps	18	23.6	17.41	15.91
main feed pumps	32	36	21.64	22.13
fire and bilge pumps	43.1	52.3	44.54	40.79
auxiliary condenser air and circulating pump	44.6		43.21	
Speed of ship, knots	18.851		17.939	
Slip of propellers, in percent of their own speed, based on mean pitch	13.78	14.01	11.12	12.28
Air pressure in fire rooms, in inches of water	0.94		0.6	
Cut-off, in decimal of stroke:				
H. P. cylinder	0.852	0.852	0.73	0.70
I. P. cylinder	0.726	0.726	0.73	0.73
F. L. P. cylinder	0.687	0.687	0.69	0.69
A. L. P. cylinder	0.687	0.687	0.69	0.69
Mean effective pressures:				
H. P. cylinder	111.4	112.2	108.3	109.5
I. P. cylinder	53.1	53.7	37.55	38.18
F. L. P. cylinder	20.1	21.6	15.76	15.42
A. L. P. cylinder	21.9	22.5	16.54	16.04
Mean equivalent pressure, referred to combined area of L. P. pistons	57.1	57.94	45.43	45.36
Indicated horsepower, main engines:				
H. P. cylinder	2,688	2,713	2,430	2,443
I. P. cylinder	3,450	3,509	2,268	2,301
F. L. P. cylinder	1,818	1,876	1,265	1,235
A. L. P. cylinder	1,891	1,951	1,327	1,285
Totals	9,847	10,049	7,290	7,264
Total, both main engines	19,896		14,554	
main air, circulating, feed and hotwell pumps	339		232	
all other auxiliaries in operation	337		330	
Total, all machinery	20,572		15,116	
Total I. H. P. per sq. ft. grate	18.702		13.74	
Sq. ft. H. S. per total I. H. P.	2.564		3.49	
Temperatures, degrees Fahrenheit:				
atmosphere	58.7		61.6	
engine rooms, working level	78.4		83.	
fire rooms, working level	85.3		90.1	
injection	51.4		62.3	
discharge	110.		114.9	
hotwell	92.8		95.	
feed	178.4		182.1	
smoke pipes	577.		479.	
Coal, New River, hand picked:				
pounds per hour, total	42,896		—	
per sq. ft. of grate	38.996		—	
per I. H. P. main engines	2.156		—	
per I. H. P. total	2.085		—	



CARDS FROM FOUR-HOUR FULL-POWER TRIAL TRIP.

between signals was increased to 60 seconds, making the firing period eight minutes instead of four. No coal tally was kept on this trial.

Each watch during this trial consisted of one chief engineer and the following number of men:

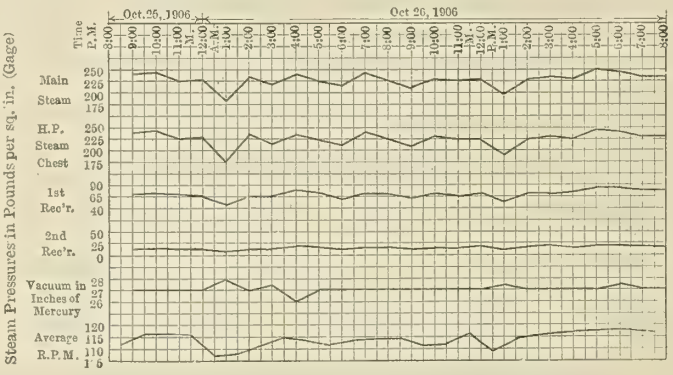


CHART FROM PORT ENGINE ROOM, TWENTY-FOUR-HOUR TRIAL.

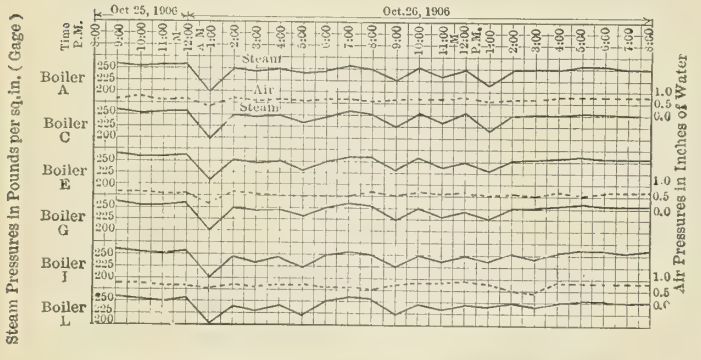


CHART FROM STARBOARD FIRE-ROOMS, TWENTY-FOUR-HOUR TRIAL.

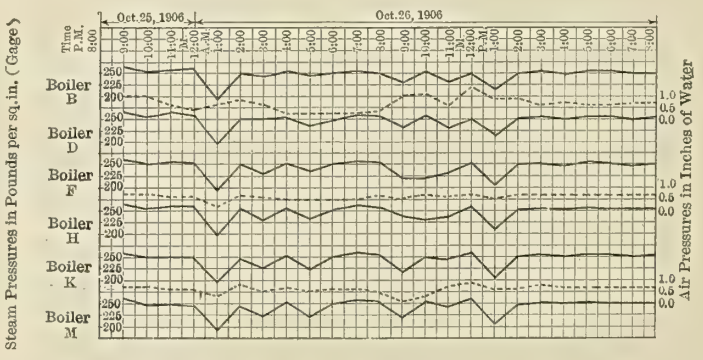


CHART FROM PORT FIRE ROOMS, TWENTY-FOUR-HOUR TRIAL.

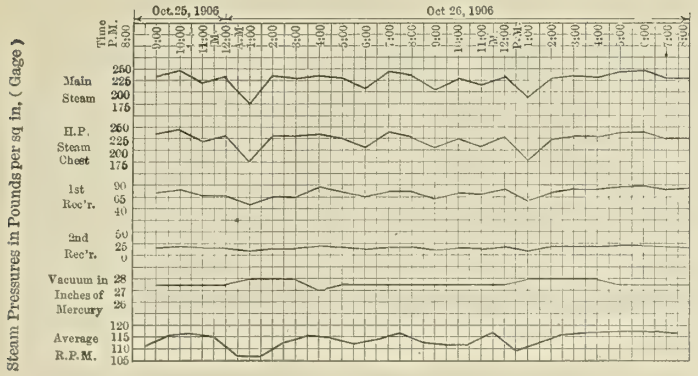


CHART FROM STARBOARD ENGINE ROOM, TWENTY-FOUR-HOUR TRIAL.

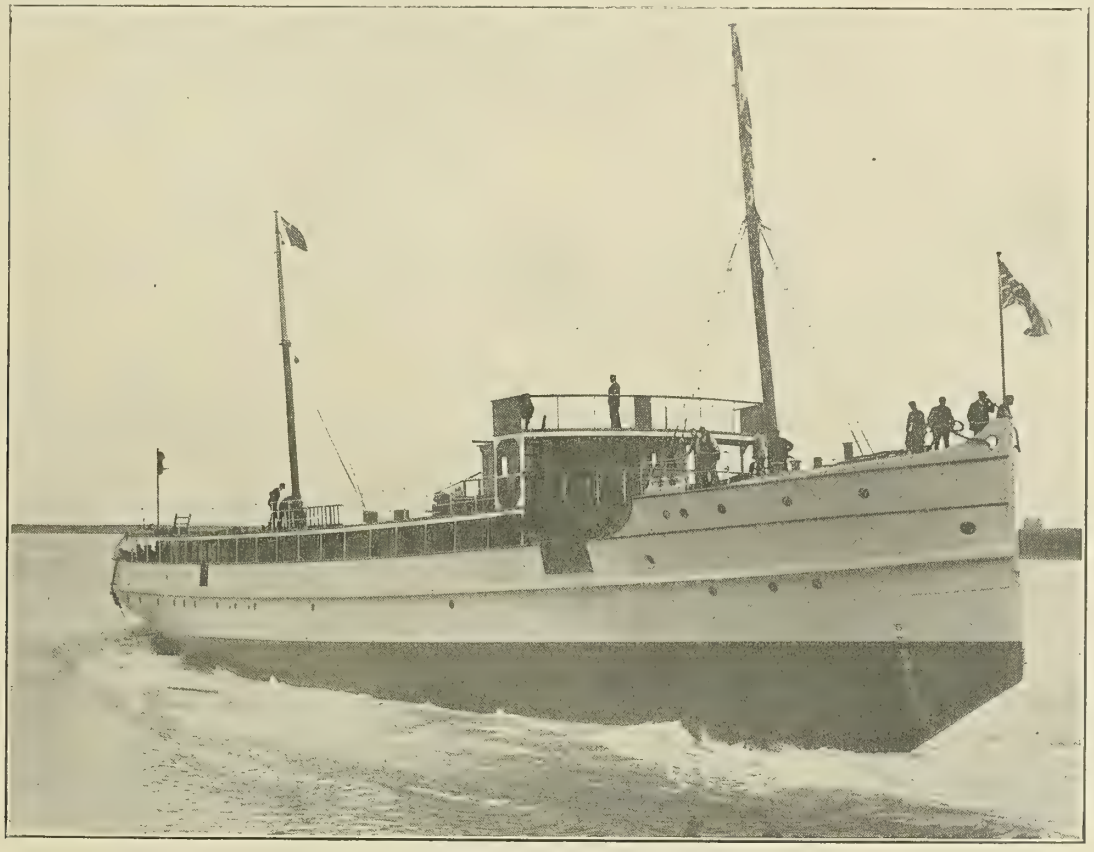
Engine Room: 3 assistant engineers, 4 machinists, 12 oilers, 5 pump men, 1 store keeper; total, 25.

Fire Room: 1 assistant engineer, 24 firemen, 24 coal passers, 6 water tenders, 3 blower men, 1 machinist, 1 ash hoist man; total, 60; grand total, 86.

eral equipments are in all respects to the requirements of the Board of Trade and the Canadian Steamboat Inspection Act.

There are two sets of inverted, vertical, direct-acting triple expansion surface condensing engines, having three cylinders working on cranks placed at angles of 120 degrees with each other. The sequence is high, low, and intermediate when going ahead. The engines, running at 130 revolutions per minute, will develop collectively 2,300 indicated horsepower. The cylinders are respectively 19, 30 and 49 inches in diameter, with a stroke of 27 inches. There are cast iron liners in the high-pressure cylinders only. The steam distribution valves are of the piston type for the high-pressure cylinders, trick type for the intermediate-pressure cylinders, and double ported flat form for the low-pressure cylinders. Each is actuated by Stephenson valve gear of double eccentric link motion, with direct acting reversing gear. The columns are box section iron castings. Centrifugal pumping engines for supplying the circulating water are fitted for each condenser, but there is a cross connection, so that either pump can circulate through either or both condensers.

Two sets of propellers are provided—a light set for summer



LAUNCHING OF THE CANADIAN ICE-BREAKING STEAMER LADY GREY.

The Lady Grey.

We present a photograph of the new ice-breaking and surveying steamer *Lady Grey*, built by Vickers, Sons and Maxim, Ltd., Barrow, for the Canadian government, and specially designed to break ice in the River St. Lawrence for navigation in the winter season. She will also be used by the marine and fisheries board for surveying the coast and channels, and powerful pumps are fitted for salvage work. The *Lady Grey* is also fitted with towing gear and has great engine power for towing service when required.

Her dimensions are: Length between perpendiculars, 172 feet; breadth molded, 32 feet; depth molded, 18 feet; draft normal, 12 feet; draft, mean when breaking ice, 13 feet; displacement, 1,055 tons; speed, 14 knots. The hull is of great strength to withstand the ice floes and to pound the ice. Fittings and gen-

use, and a heavy set specially designed for ice work. The propellers are all of the built-up type, with three blades.

Steam is supplied at a working pressure of 180 pounds per square inch by four single-ended cylindrical boilers, 12 feet 9 inches in diameter and 10 feet 6 inches long. Jones' underfeed mechanical stoker system, with fan for air supply, is fitted, and in the stokehold there is a See ash ejector, in addition to two hand ash hoists.

The officers and engineers are accommodated in a large steel deckhouse on the main deck, with mess room, galley and pantry, and a spacious saloon. A smaller private saloon and suite of cabins is provided in a teak deckhouse on the hurricane deck, and cabins are also provided on the lower deck aft. The crew are housed in the forecastle and on the lower deck forward.

The ship has an electric lighting installation, and there is a

16,000-candlepower searchlight. The current is supplied by duplicate sets of engines and dynamos.

For her particular work the bow has been constructed of the "Canadian" type, for mounting and breaking green ice, and for forcing through pack ice. A belt of heavy plating is fitted fore and aft, in depth considerably above and below the water line. The cross sectional form of the ship is designed to resist the lateral pressure of the ice. To counteract 'thwartship pressure, double framing is introduced in intermediate channels. These additional members extend, forward, from the keel to the main deck, and aft they are between the bilge and the main deck. The side plating is increased in thickness from the stem to a point well aft of amidships.

The hull is divided into six watertight compartments, and a double bottom extends from the forward to the after peak bulkheads. The compartments forward and aft of these bulkheads are arranged as ballast tanks, into or from which water can be pumped quickly, and the trim altered as required in riding over the ice. These tanks are connected by a large pipe with the ballast pumps. There are steam windlass and cargo winches, and steam capstans forward and aft for warping. With a large rudder is proportionately powerful hand and steam steering gear. The rudder head above water level is protected by a heavy casting, and the gear is constructed to withstand excessive pressure when working among ice.

Benjamin Taylor.

Half a Century of Ship Construction.*

by James Gilchrist.

With reference to marine engines and steam propulsion, the last half century has seen many changes. Steam pressures have risen from 20 pounds to 300 pounds per square inch, and in order that these pressures might be economically used, various designs of engines had to be adopted. About 1861, when steam pressures began to increase, the boilers gave trouble to engineers on account of the excessive precipitate, due to the evaporation of salt water with which they were fed, and to overcome this difficulty surface condensers were introduced, so that the boilers might be supplied with distilled water, instead of with impure condensed water obtained largely from the sea. The success of surface condensation was at once assured, and ever since it has been universally adopted. In connection with this subject, namely, the desirability of allowing no deleterious matter to enter the boilers, fresh water distilling plants and also grease extractors are now fitted in all well appointed vessels.

About 1867 compound engines came greatly into favor, although Messrs. Randolph & Elder, the pioneers of this design, had made them at a much earlier period. At first the boiler pressure was usually 60 pounds, but as time rolled on, and engineers became accustomed to them, pressures increased until 120 and 130 pounds was quite common. This type of engine was largely used for land purposes, and almost universally on board steamers until 1881, when Messrs. Robert Napier & Sons built the first triple expansion compound engines for the steamship *Aberdeen*. Her cylinders were 28, 42 and 70 inches in diameter by 54-inch stroke, and her boiler pressure 125 pounds. These engines were designed and constructed by Dr. Kirk, one of our deceased members, and so great was their success and the economy obtained in coal, that a complete revolution took place in marine engineering. Shipowners became desirous of possessing triple expansion engines, and makers were quite enthusiastic in their supply, vieing with each other as to who should be most successful with their production. As pressures had rapidly increased with the compound, so did they rise in the triples, and now, in modern vessels, pressures of 215 pounds are frequently used, although many engineers affirm that no economy is obtained above 180 pounds, and that, for pressures above this, quadruple expansion engines should be adopted. Of this style a considerable number has been made.

I have stated that the triple expansion engine caused a revolution in marine engines, but perhaps a greater is now before us, in the shape of the turbine, which has had a most remarkable development during the last ten years, gradually growing into favor with both the Admiralty and the mercantile marine.

Thurston, in one of his last contributions to technical literature, said—"Probably never in the history of engineering was so simple a machine made the object of investigation by so large a number of able men, inventors, constructors, engineers, and men of science, and the subject of such extensive experimental research." It is, therefore, to be hoped that all the time, care, and attention which has characterized these researches may be fraught with success, and that the large sums of money spent on experiments may not have been spent in vain. On the contrry, it may be found that not only is the turbine the machine which can give forth the greatest power for the least possible weight, but that it can also give the greatest horsepower for the least quantity of fuel.

During the last fifty years, great developments have been made in passenger and cargo steamers. In 1857, perhaps the largest vessel, excluding the *Great Eastern,* was the paddle steamer *Persia,* of 3,600 tons; while now there are a goodly number of vessels exceeding 20,000 tons. During this year the two largest vessels ever built were successfully launched—the *Lusitania,* from the works of Messrs. John Brown & Co., Clydebank, and the *Mauretania,* from Messrs. Swan, Hunter & Wigham Richardson, Ltd., Newcastle-on-Tyne. Figures convey a somewhat bare idea of size, but if these two vessels are compared with the *Great Eastern* (Brunel's leviathan), it will at once be noticed what an enormous difference there is:

	Great Eastern.	*Lusitania.*
Length	692 feet	790 feet
Breadth	80 feet	88 feet
Depth	..	60 feet
Displacement	27,000 tons	45,000 tons
Speed	14 knots	25 knots

These two mammoth ships are each to be driven by turbines of a collective horsepower of 70,000, and as the owners (the Cunard Co.) have obtained most valuable data from the running of the *Carmania,* a turbine steamer of 20,000 tons, the new boats will get the full benefit of this data. Everything augurs well for their ultimate success, and, no doubt, when in actual service, Great Britain will once more possess the greyhounds of the Atlantic.

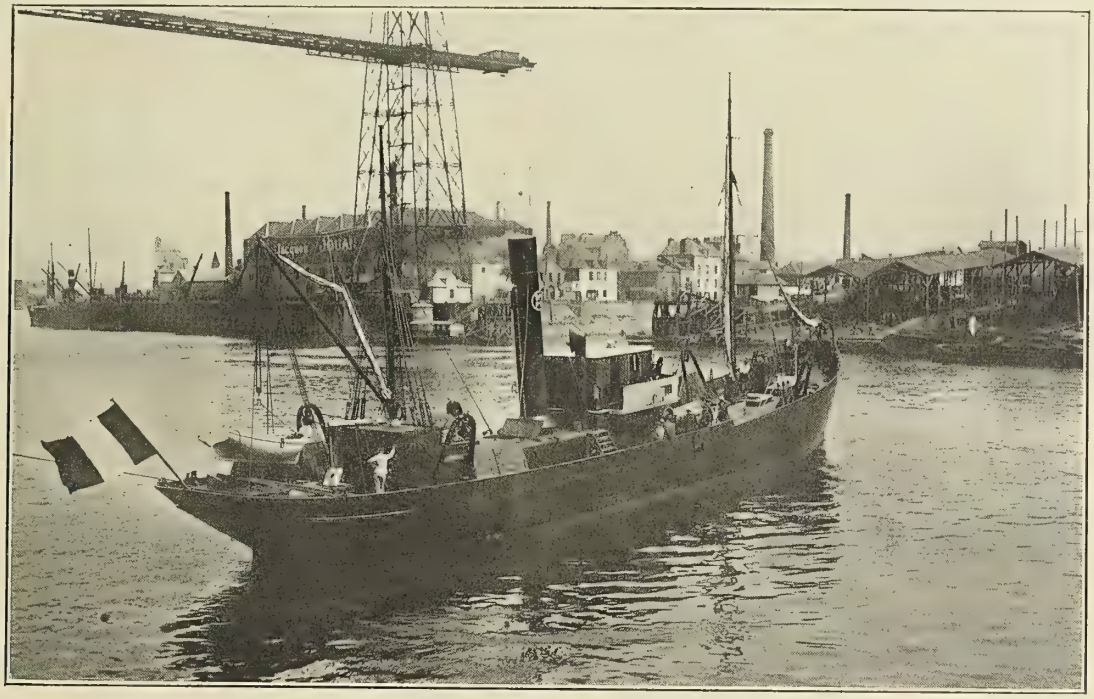
Sailing ships are now few and far between. Cargo steamers, commonly called "tramps," have practically driven them off the seas. These "tramps" carry large cargoes, with a comparatively small crew, can travel more speedily than the "sailer" over a long voyage, and as their first cost is moderate, shipowners find them more remunerative than canvas-driven vessels.

On this subject, however, there was an article last week in the *Glasgow Herald,* giving some particulars of Germany's huge sailing ship, the *R. C. Rickmers,* which is fitted with auxiliary engines for driving her in a light condition at eight knots, and when loaded at six knots, in calm weather or when contrary winds prevail. The vessel is probably the largest sailing ship afloat. She is 441 feet in length over all, and 53 feet 8 inches in breadth, displaces, when light, 3,350 tons, and has accommodation for 8,000 tons of cargo. Her gross register tonnage is 5,548 tons. Her main mast is 177 feet from the deck level, and on this and her other four masts she carries upwards of 50,000 square feet of canvas. On her first voyage she made splendid time, averaging under sail on long periods 13 knots—for eight hours she averaged 15¾ knots—while the triple expansion engines of 750 indicated horsepower, fitted to drive a Bevis screw, enabled her to make from 6 to 6½ knots as a minimum speed. These results are regarded as suggestive of the fact that the days of the sailing ship may not be over, and much interest is

* Abstract of the President's address, read October 23, 1906, before the Institution of Engineers and Shipbuilders in Scotland.

consequently being taken in the application of the petroleum engine for driving such craft instead of using a boiler and steam engine.

Our navy has also considerably altered. The wooden walls of the past have now changed into iron-clad battleships; first, second and third class cruisers, most of them belted with armor plates; scouts, torpedo-boat destroyers, torpedo-boats, submarine boats, etc. The whole system of naval warfare has been revolutionized, and much valuable information gained by the experiences of the sea fights of Cuba and the Sea of Japan.



THE FRENCH STEAM TRAWLER MORELLA ON THE LOIRE, AT NANTES.

Progress of Naval Vessels.

The Bureau of Construction and Repair, Navy Department, reports under date of January 10, 1907, the following percentage of completion of vessels building for the United States Navy:

			Dec. 1	Jan. 1
BATTLESHIPS.				
Nebraska	19 knots.	Moran Brothers Co.	97.5	98.1
Vermont	18 "	Fore River Shipbuilding Co.	96.	97.5
Kansas	18 "	New York Shipbuilding Co.	95.2	96.9
Minnesota	18 "	Newport News Co.	98.	98.5
Mississippi	17 "	Wm. Cramp & Sons.	69.6	70.68
Idaho	17 "	Wm. Cramp & Sons.	65.15	66.78
New Hampshire	18 "	New York Shipbuilding Co.	57.	60.8
South Carolina	19 "	Wm. Cramp & Sons.	3.14	5.03
Michigan	19 "	New York Shipbuilding Co.	1.51	3.01
ARMORED CRUISERS.				
California	22 knots.	Union Iron Works.	97.	97.4
South Dakota	22 "	Union Iron Works.	93.5	94.8
North Carolina	22 "	Newport News Co.	66.35	69.16
Montana	22 "	Newport News Co.	60.62	63.59
SCOUT CRUISERS.				
Chester	24 knots.	Bath Iron Works.	54.83	59.42
Birmingham	24 "	Fore River Shipbuilding Co.	52 7	56.6
Salem	24 "	Fore River Shipbuilding Co.	52.7	56.5
SUBMARINE TORPEDO BOATS.				
Cuttlefish	.....	Fore River Shipbuilding Co.	90.	90.
Viper	.....	Fore River Shipbuilding Co.	82.72	82.72
Tarantula	.....	Fore River Shipbuilding Co.	92.	92.
Octopus	.....	Fore River Shipbuilding Co..	81.1	81.1

The Latest Type of French Steam Trawler.

The photograph shows the latest type of French steam trawler, intended to make trips to the Iceland and Newfoundland fishing grounds, as well as to the Senegal and Morocco coasts. They belong to the Société Française des Pêcheries à Vapeur of Paris, and were built in the De la Brosse & Fouché yards, at Nantes. They have the following dimensions: length 158 feet, breadth 23 feet and depth 11 feet. Their gross tonnage is 299 tons, and they are fitted with triple expansion engines of 450 horsepower. Steam is furnished by a single boiler of the usual type.

According to the last Act on the "Shipbuilding Subsidies," the builders will get from the government a pretty penny for each of these trawlers: 175 francs ($35 or £7) per gross ton for the hull, and 210 francs ($42) per ton of machinery on board, including the triple expansion engine, boilers, pipes, steering apparatus, refrigerating plant, etc. There is some trouble between the builders and the government about this class of vessel, but, as the Act covers "every sea-going ship or vessel," it is probable that this matter will be settled to the benefit of the builders.

On the other hand, the owners receive from the government a subsidy of 12 to 20 francs ($2.30 to $3.86) per 100 kilograms (221 pounds) of fish delivered, and can sell their takes abroad, without any loss of this privilege, except for cod.

The particulars of the machinery are as follows: diameters of the cylinders 12, 20 and 32 inches; stroke, 24 inches; number of revolutions, 150 per minute. The one boiler has two furnaces, and operates at a normal pressure of 168 pounds per square inch.

J. Peltier.

Lloyd's Shipbuilding Returns.

Work on hand in British shipyards at the end of December showed a reduction of 98,000 tons as compared with that on hand at the end of September, and a total reduction of 242,000 tons during six months. The tonnage reported under construction December 31 amounted to 1,166,989 gross tons of mercantile vesels, of which 1,150,576 tons in 445 vessels were to be propelled by steam and 16,413 tons in 36 vessels by sail. The average steam tonnage is thus 2,585 tons, while the sailing vessels average 456 tons.

At the same time there were under construction 49 war vessels, aggregating 205,858 tons, of which 43 of 186,038 tons were for the British navy and the balance for foreign navies. Of the British ships included in this list, one was of the *Dreadnought* type, three were of the *Invincible* type, three of the *Shannon* type, two of the *Lord Nelson* type and two of the *Warrior* type. These eleven ships are all of great power, and

aggregate in displacement 173,650 tons, making an average of 15,706.

The returns indicate tonnage under construction in other countries as follows: France, 55,537; Germany, 202,911; Holland, 45,161; Italy, 73,471; Japan, 61,302; United States, excluding the Great Lakes, 136,270 tons.

THE DIMENSIONS, PROPORTIONS, AND FORMS OF SHIPS.*

BY H. B. DONALDSON.

When discussing any special branch of naval architecture, particularly such a one as my subject, it is difficult—in fact, well-nigh impossible—to confine one's attention rigidly to the topic under consideration, so many are the side issues. Each particular class possesses features distinctive to itself which the naval architect must perforce consider to insure a satisfactory design.

For example, ships may be classed under three distinct headings: war vessels, whose sole duty it is to safeguard the interests of the empire throughout the globe; passenger vessels, for the safe and speedy conveyance of travelers from one country to another; and cargo steamers, for the purpose of effecting an interchange of the products of various countries.

Perhaps of the three, warships call forth the greatest amount of ingenuity on the part of the designer. Being in reality a floating battery, armament is naturally of the primary consideration. To provide a reasonable amount of protection over the vitals, efficient protection must be devised, either in the shape of thick protected decks, as in many of our fast cruisers, or a combination of side armor and protective plating on a deck or decks.

This involves at the outset a very large expenditure of weight on armor and armament. Quick steaming and large radius of action—most important characteristics—provide other items to which must be allotted a large share of weight, and introduce the question of dimensions and form consistent with an economical expenditure of fuel, while the most important feature of all, sufficient stability, introduces a requirement to which all the foregoing must, if necessary, be subservient.

When designing any new type of vessel, it is frequently found that all these requirements are diametrically opposed one to another, so that the finished result presents a vessel in which all conflicting elements are, as far as possible, eliminated, and which possesses the maximum amount of armament, armor, speed, coal supply and safety it is possible to give under the existing conditions.

The distribution of guns at a more or less great height above the load waterline, a large amount of armor, also with its common center of gravity at a considerable distance from the bottom of the keel, associated with the displacement to carry all the weights involved and the fine form inseparable from the high rate of speed, find as a natural sequence a large proportion of beam in terms of length.

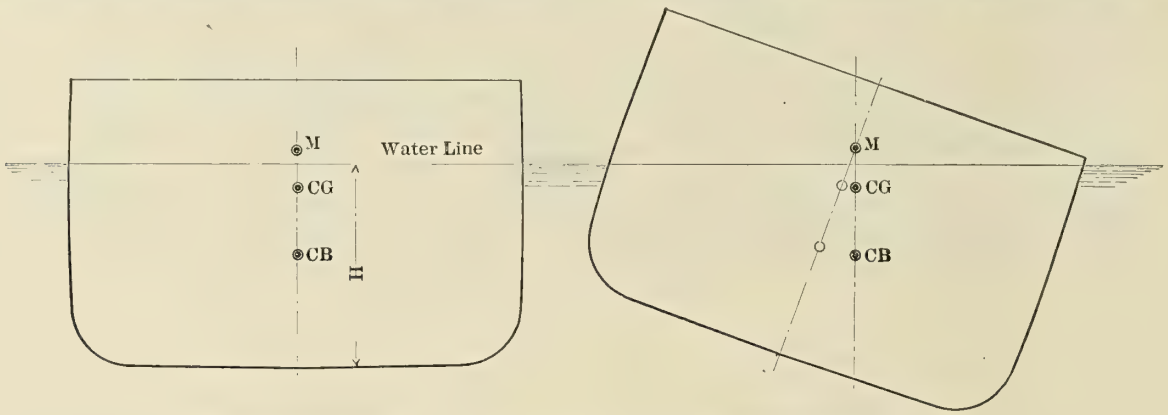
Outside requirements will further call for consideration. The draft must be limited by the depth of water at the various harbors the vessel will visit, and as docking is of a more or less frequent occurrence, the breadth must not exceed that of dock entrances.

To grasp the effect of different proportions of dimensions one to another and on the safety of the ship, a brief consideration of the fundamental principles of stability is necessary.

Let L = length,
B = breadth,
H = draft,
D = displacement,
Cf = coefficient of fineness,
I = moment of inertia of waterline,
$C\,B$ = center of buoyancy,
$C\,G$ = center of gravity of ship,
M = transverse metacenter.

The metacenter is an imaginary point in the center line of a ship in the upright condition, produced by the intersection of a line drawn vertical to the new waterline of the ship at any angle of heel, through the new position of the center of buoyancy, and fixes a limit above which the center of gravity of the ship must not pass under conditions of stable equilibrium.

The distance $B\,M$, between $C\,B$ and M (see Fig. 1), is determined by the displacement and the area of the waterline, and is arrived at by the formula $B\,M = \frac{I}{D \text{ in cub. ft.}}$. Now I = sum of waterline breadths, cubed, multiplied by the distance apart of the stations at which the breadths are measured; so that the full formula may be written $B\,M = \frac{2}{3}\int \frac{\left(\frac{B}{2}\right)^3 dx}{D \text{ in cub. ft.}}$, or put into a more general and approximate form $B\,M = \frac{K \times L \times B^3}{D \text{ in cub. ft.}}$, K being a coefficient depending upon the form of the waterline. Simplifying this equation it becomes $Y\frac{B^2}{H}$, the coefficient Y being the quotient of K and Cf.



In Upright Condition — In Inclined Condition

FIG. 1. DIAGRAMS SHOWING THE POSITIONS OF THE VARIOUS CENTERS INVOLVED IN STABILITY.

From the note on the distribution of weights it will be readily deduced that the common center of gravity of the ship will be at a considerable proportion of the depth from the keel. In order that the metacenter shall not fall below this position, the dimensions and form must be such as to insure an adequate height.

Reverting to the formula $B\,M = \frac{K \times L \times B^3}{D}$ it will be seen that B enters the equation in the third power. Therefore any increase in the breadth will have a proportionately greater effect on the stability than a change in any other dimension; added to

* *The Engineering Review*, London, September, 1906.

this the fine form of immersed body and waterline to comply with the requirements of speed, it is obvious that the breadth will diminish rapidly before and abaft the widest section, hence a considerable amount of breadth is of paramount importance in the first instance to insure satisfactory stability (see Fig. 2, curve *A*).

The question of freeboard is not one that requires the careful amount of manipulation associated with the design of cargo carrying steamers, as the inherent requirements of a war vessel provide a much greater amount than would be assigned under Board of Trade regulations. The naval designer has one great advantage over his colleague in the merchant service, inasmuch as all the heavy weights, which go to make up the displacement, are fixed, and he is consequently in a position to produce a vessel whose sea-going qualities can be estimated before even she is put in commision.

The centers of gravity of armament, armor, hull, machinery, outfit, etc., can be estimated with great accuracy by detailed calculation, or arrived at approximately by reference to tabulated data of somewhat similar ships already built, while the position of the metacenter is, of course, arrived at by direct calculation.

The effect of the consumable stores, such as ammunition, bunker coal, fresh water, provisions, etc., can be easily arrived at; hence all the conditions under which the ship is likely to sail may be predicted, and provision made against any contingencies that may arise during service.

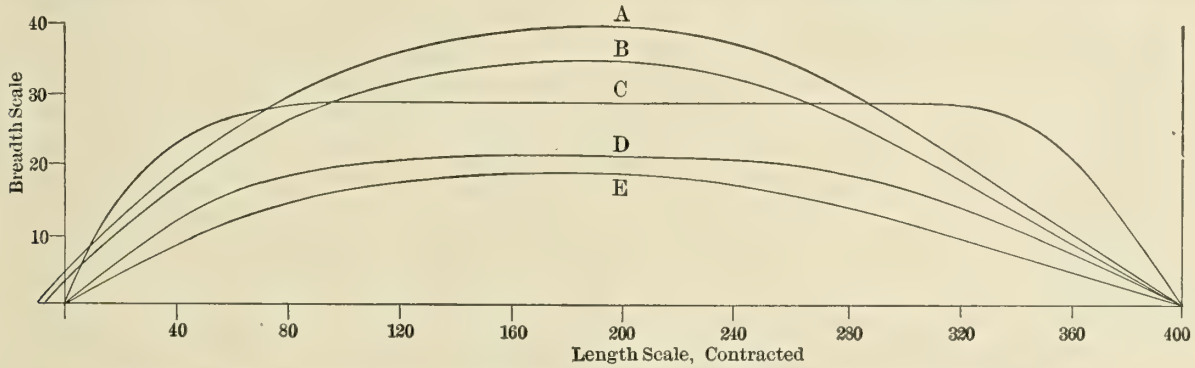


FIG. 2. TYPES OF LOAD WATERLINES OF VARIOUS CLASSES OF VESSELS, STANDARDIZED TO A LENGTH OF 400 FEET.

The old fallacy that large beam and great immersed midship area in themselves were derogatory to speed has been dispelled for all time by the exhaustive experiments commenced by the late Mr. Froude, and carried on later by his son at the government experimental tanks at Torquay, and it is largely to the invaluable researches of these gentlemen that we owe the present state of our knowledge.

An illustration of the differences of waterlines may be seen by reference to Fig. 2. For convenience of comparison, all the types chosen have been standardized on a length of four hundred feet.

Curve *A* shows the load waterline of a modern first class battleship. Here it will be noted that there is absolutely no parallel middle body, which forms so prominent a feature in almost all classes of merchant vessels, the entrance and run being made as free as possible, consistent with the required stability and displacement.

Curve *B* represents the load waterline of a modern 23-knot armored cruiser. This class of vessel is gradually assimilating the features of a first class battleship; the absence of a primary armament of heavy 12-inch breech-loading guns prevents its being placed in the same category as regards weapons of offence, but the additional four or five knots gives it a great advantage as a mobile unit in naval warfare.

Curve *D* introduces a type of form common to high class Atlantic liners, while curve *C* shows a typical instance of the load waterline of a modern tramp steamer; the bluff ends and great length of parallel middle body supply the inertia lost by a proportionately diminished beam, and while this form is admirably suited within certain limits to the work required, it will be seen that its application to a high speed vessel would result in a disastrous failure, the differences in speeds, involving widely different wave resistances, etc., being so great.

Curve *E* shows the load waterline of a modern 30-knot torpedo boat destroyer, the lines being exceptionally fine in order to attain the great speed.

Turning from the consideration of warships to that of merchant vessels, the conditions at once become widely different.

In the place of a number of items of great weight, distributed at known positions throughout the ship, we have to deal with a floating body in which the initial weights and centers to consider are hull and machinery, the sum total resulting in a displacement very much lighter than the displacement when floating at the assigned load draft, the greater the difference the greater the satisfaction of the owner.

In the case of passenger vessels, this does not apply to any great extent in first class boats, or at any rate only a very small amount of capacity is available for carrying cargo. The high rate of speed means that an enormous amount of coal consumption is necessary in order that it may be attained. Here again the variations in draft are not so great, for the permanent weights—hull, machinery and outfit—comprise so great a proportion of the total displacement that the naval architect is able to predict, with a considerable degree of certainty, the changes in metacentric height likely to occur, and can consequently determine on such high dimensions and proportions as to satisfy any alterations which may arise to disturb the position of the center of gravity, and while the position of the metacenter will in most cases fall from the locus it occupies in load condition, yet this drop is of so small an amount as to be hardly appreciable; indeed, it is most probable that by the time the bunker coal and stores are about exhausted the metacenter will be on the upward grade again. The character of the metacentric curve for a vessel of the fast liner type is illustrated in Fig. 3. The reason for the great increases in height at lighter drafts is that the displacements decrease at a much more rapid rate than the moments of inertia of the respective waterlines.

In cargo boats, steaming at only ten or eleven knots, the horsepower required amounts to a very modest figure, so that the coal consumption, and consequently space and weight allotted to bunkers and machinery, drops accordingly. The weight of the outfit, covering such items as accommodation, boats, and the hundred-and-one fittings which go to make up a well-equipped passenger vessel, are cut down to a minimum, leaving a very large balance of displacement between actual light weight of ship —or light displacement—and the load displacement which is utilized to carry cargo, and is termed "deadweight."

In a case of this kind it is practically impossible to foretell the positions the centers of gravity may occupy during the voyage, as it depends entirely on the nature of the cargo carried and the manner in which it is stowed. Incidentally it may be mentioned in this respect, that a great amount of laxity is commonly

displayed in loading vessels; the stevedore—when a general cargo is carried—does not consider, in fact, probably does not know, how the disposition of weights may affect the sea-kindliness, but packs everything away as though it were a matter of supreme indifference to everyone concerned.

The height above the keel of the center of gravity of an ordinary cargo carrier may vary anywhere between 0.62 and 0.7 of the molded depth; usually for modern one, two, three or spar decked ships having poops, bridges, and forecastles, the first figure is nearer the mark.

In light condition the *G M*, or measure of initial stability, works out at about 12 feet in cargo steamers of the latest type.

Take an instance selected at random from the tabulated data of a large number of steamers—a vessel 325 feet by 46 feet 10 inches by 26 feet 10 inches. The actual metacentric height measures 11 feet 6 inches at light draft, that is, the ship ready for sea, with fresh water on board, but no bunker coal or stores. At load draft the *G M* drops to about 2 feet 9 inches with a homogeneous cargo of just sufficient density to completely fill the holds and to immerse her to the load draft.

Authorities differ as to the correct measure of initial stability necessary to insure absolute safety under the various conditions

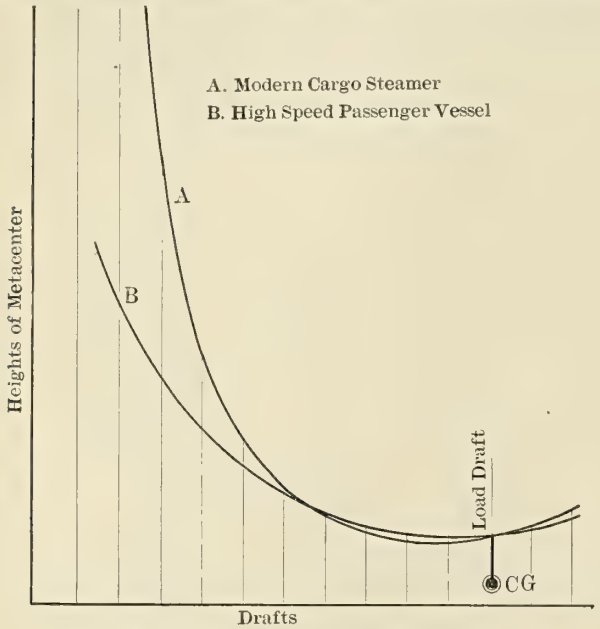


FIG. 3. TYPICAL METACENTRICAL CURVES.

of lading a ship experiences during her career, and to insure sea-kindliness. Many consider 2 feet a standard below which it it not advisable to go, while others maintain that 1 foot is sufficiently adequate, indeed, several cases have come under the author's notice of vessels possessing less than 1 foot *G M*, and without exception these have proved to be most comfortable sea boats. Whichever figure is decided upon, there still remains a very great difference between that and the amount possessed by the above examples.

Within the last two years or so the tendency has been to further increase the beam, without in any way increasing draft; in fact, such at present is hardly permissible for general trading purposes, as the depth of water in the majority of ports precludes any such increase.

For some reason or other, beam has been fixed on as the elastic dimension, and has been stretched to a degree which scarcely favors the turning out of vessels possessing the lightest weight of hull for cargo carried. This great proportion of beam and fullness of form common to the great majority of cargo steamers produces an excessive amount of *G M*, which aggravates rolling in a sea-way and destroys all features of sea-kindliness, besides bringing heavy strains to bear on the ship's structures, and rendering them most uncomfortable.

It may be argued, in many trades, that cargoes of such a density may have to be loaded as to necessitate a portion being carried on decks in order to bring the vessel down to somewhere near her Plimsoll marks, and in cases in which vessels have to carry timber. Assume that this condition will be met in the above mentioned instance: the effect of a deck cargo will be to move the common center of gravity vertically about 1 foot 3 inches above its original position, leaving a metacentric height of about 1 foot 6 inches.

In view of the fact that a considerable number of vessels put to sea with the center of gravity approaching the metacenter within much closer limits, and have proved themselves by long experience to be excellent sea boats, there are indications that, for vessels employed outside of the timber trade, it would be profitable to diminish beam, and, indeed, in many instances where deck cargoes of timber, machinery, etc., are carried, it would most probably be found that a slightly diminished beam would in no way interfere with the seagoing qualities or safety of the vessel; while it must be obvious to everyone that a vessel possessing suitable proportions of length, breadth and depth will undoubtedly be more capable of maintaining reasonable headway in heavy weather than one in which beam reaches an abnormal ratio; further, experience has shown that length is favorable to the maintenance of speed.

It is interesting to note that a new type of steamer has recently been evolved on the northeast coast,* in which side tanks are fitted at the top sides, as shown on Fig. 4, with the two-fold object of immersing the vessel, when traveling light, to such an extent as to submerge the propeller in order to minimize racing while encountering head seas; and to reduce what has already been recognized in some quarters as an excessive amount of initial stability or metacentric height when light. The sloping sides form the bottom of the water ballast tanks, and also convert the steamer into one of the self-trimming type.

The conditions governing the actual forms are as many and varied as those governing dimensions. Each particular class possesses features distinctive to itself, though there are two distinct headings under which this requirement may be grouped, viz., vessels which travel at a high rate of speed; and those in which cubic capacity is of primary, while speed is of only secondary, consideration. The latter may be subdivided into those which carry deadweight cargoes, and those for light measurement goods.

As mentioned earlier, warships and high-class passenger ships must, owing to the nature of their service, possess high speed, hence the general form is made as fine as possible with due regard to the previously mentioned requirements.

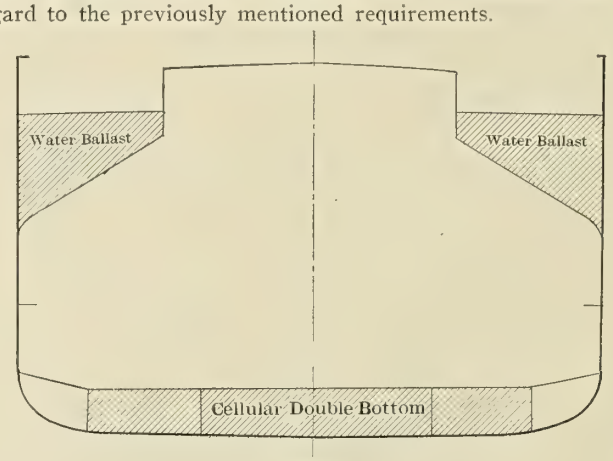


FIG. 4.

The form of cargo vessels pure and simple is, on the other hand, generally determined by considerations of dead weight to be carried, and capacity consistent with the lightest weight of hull, so that the scope for exercising ingenuity in devising forms is narrowed down very considerably, though there are, of course, certain general principles which must—or ought to—be adhered to.

*Of Great Britain.

The midship section, see Fig. 1, very closely approximates a rectangle; a small amount of rise of floor is given to enable loose water to drain to the center line, in the proximity of which are placed suctions to pump the tanks dry, and the bilge is given an easy round. Tumble home may or may not be a feature of the section, according to the fancy of the designer or to the consideration governing scantlings. In order that displacement and capacity may be attained on as small dimensions as possible, the midship section is continued as far forward and aft as practicable and consistent with sweet lines.

Experiment has demonstrated and experience confirmed that a full fore body relative to the after body results in a more economical form for propulsion. The well-known parallel that a wedge driven blunt end through the water requires a less expenditure of power than one driven point first illustrates this principle.

Imagine a propeller placed just clear of the actual deadwater, it can be readily recognized, without the aid of any elaborate mathematical formula, that the resistance will be further greatly increased. The action of the propeller on a ship in drawing a mass of water towards itself increases the speed of the water past the ship's skin, and the fuller the run the greater the augmented resistance, so that it may be laid down as a general principle that the center of gravity of the displaced water—or the center of buoyancy—should be a certain distance forward of amidships; in practice this usually amounts to about 2 feet.

The forward sections particularly, and to an only somewhat lesser degree the after sections also, should be more or less club-footed, in order to provide as much buoyancy as possible low down in the water, so that when the ship is pitching, and the ends are alternately out of and then buried in the sea, sufficient upward support may be given to prevent any undue plunging, while to throw the water away from, rather than on to the decks, a considerable amount of flam or flare should be given forward, and extending as far aft as the contour of the lines will permit. The after sections, owing to their inherent shapes, fulfil this requirement.

Seamen speak in most feeling terms of vessels which bury their heads in every sea they encounter, a property which is entirely due to giving the forward sections a too pronounced fine V shape. The buoyancy of such a form does not make itself felt until a considerable proportion of the section is immersed, and the dynamic force gathered in the consequently greater downward plunge gives a still further immersion, so that by the time the plunge is arrested the deck ships heavy seas, and the vessel earns the sobriquet of a wet ship.

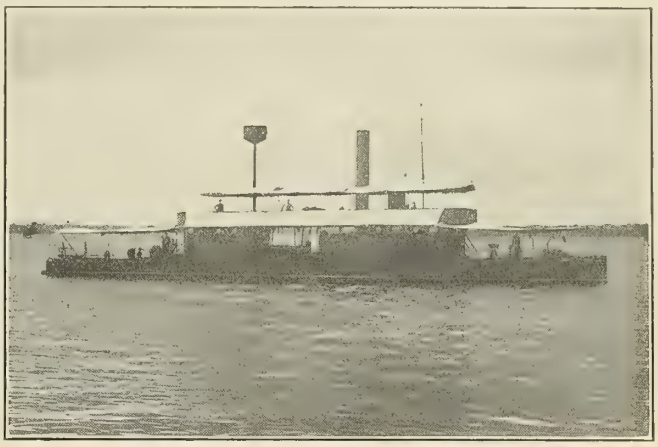
NEW GUNBOATS FOR THE BRAZILIAN GOVERNMENT.

The gunboats which we herewith illustrate are two of the seven gunboats—four of the larger and three of the smaller—recently constructed by Yarrow and Company for the Brazilian government for service on the Amazon. The dimensions of the four twin screw shallow draft gunboats are:

Length, 120 feet; beam, 20 feet; depth, 4 feet 9 inches. With a load of 25 tons they draw 25 inches, and have a speed of 12½ statute miles an hour. They are fitted with Yarrow's patented hinged flap, by means of which it is claimed that one mile an hour additional speed is obtained, without additional power or additional cost.

Two deck houses are provided, these being constructed of steel, one forward and one aft. The tops of these are connected by the battery deck with steel bulwarks all round, and over this awnings extend from forward to aft, as will be seen in the engraving. The forward cabin is divided into two compartments, that forward being fitted up for the commander, and the other arranged as a wardroom. The after cabin is fitted up as petty officers' quarters, and above is provided a hollow steel mast, with crow's nest at the top. Above the forward cabin is the conning tower and the steering position, and above these again a search-light platform.

From a structural point of view, the feature of the design is the method by which longitudinal strength is obtained for these shallow lightly-constructed vessels. It lies in the connection by the upper steel deck uniting the two deck-houses, the bulwarks of this upper deck forming a girder throughout the amidship portion of the vessel.

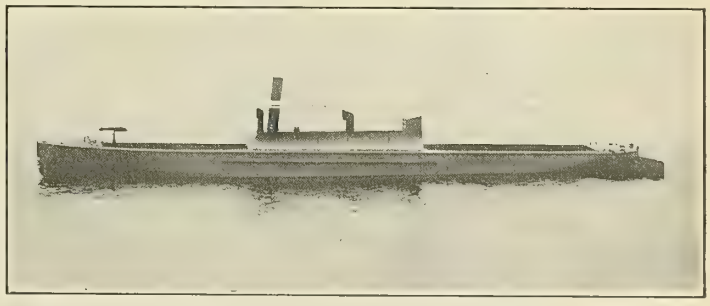


TWIN SCREW SHALLOW DRAFT BRAZILIAN GUNBOAT.

The propelling engines are triple-expansion, these being supplied with steam by a Yarrow water-tube boiler. The auxiliary machinery includes steam steering engine, distilling apparatus, circulating engine, electric light plant, fans, and pumps. A steam capstan and warping gear is fitted forward, with the necessary anchor arrangements, and the usual ship's boats are provided. These vessels were shipped in pieces, and were riveted up and launched on the banks of the Amazon.

The dimensions of the three smaller single screw gunboats are: Length 75 feet; beam, 9 feet 3 inches; depth, 4 feet. They were also constructed on Yarrow's tunnel system, with patented adjustable flap.

As will be seen in the illustration the machinery space is completely inclosed. The machinery and steering station are protected by chrome steel plates, proof against the Lee-Metford rifle fire point blank at 20 yards. The boats are fitted with two rudders, and can be steered either from forward or from a sheltered position aft of the machinery space. A wooden awning is provided, extending from end to end, and there is a short deck forward, on which, it will be seen, is placed a small gun.



SINGLE SCREW PATROL LAUNCH FOR RIVER SERVICE.

This type of launch is now attracting considerable attention, because of its suitability for expeditionary work, its characteristic features being the extreme simplicity of the machinery, the engine being non-condensing, and the boiler of the locomotive type, which is proportioned for burning wood. The draught, with steam up, is 14 inches, and on this draught a speed of 10 statute miles an hour is easily maintained. These launches were shipped entire from London, and are considered to be just what is required to keep natives under control, on some of the rivers which pass through more or less unexplored districts.

THE SHIPBUILDING YARD OF WILLIAM GRAY & COMPANY, LIMITED.

At Hartlepool on the east coast of England there was established in 1836 a yard for the building of wooden sailing ships. This was carried on by Mr. J. P. Denton, until 1862, when Mr. William Gray became associated with the firm, and in 1864 was launched the first iron steamer, a vessel of 800 tons. In 1869, the business was transferred to the dock yard at West Hartlepool, and three years later came into the hands of Mr. Gray alone, the firm name being then changed to that obtaining at present. For a number of years hulls were constructed, but not until 1883 was an engineering department added. This latter was known as the Central Marine Engine Works. In 1887 a further extension took place in the establishment, of what has been called the Central Shipyard, containing at first three berths capable of building steamers up to a length of 450 feet. In 1900 this yard was extended by the addition of two berths each 500 feet long, thus placing at the command of the firm a total of eleven berths.

OFFICES AND SOUTH YARD OF WILLIAM GRAY AND COMPANY, LIMITED.

The engine works cover an area of about ten acres, and have produced engines ranging in power up to 5,000. The quay frontage of 830 feet can be reached by new vessels from any part of the yards without leaving the dock system. The engine works consist of six principal departments: the engine shops proper, boiler shops, pattern shops, foundry, forge shop and sheer legs department. In addition to these are the usual auxiliary departments, such as copper shop, brass foundry, joiner shop, paint shop, etc. The proprietors are thus able to produce every detail required for the engines and boilers, as well as the heavy forgings and castings needed for the hulls. The number of men employed in this part of the establishment is about 2,200, and the output each year consists of twenty-five or thirty engines, amounting to a maximum of about 100,000 indicated horsepower.

The main shops are 300 feet in length, and consist of seven spans, which vary in width from 40 to 60 feet. The engine shops cover a floor area of 62,000 square feet, the entire ground floor being paved with wooden blocks. Wide skylights running the entire length of the building provide an ample supply of light.

QUAY AND SHEER LEGS IN FRONT OF THE ENGINE WORKS.

This firm has done some of the largest construction in England, and has been noted for a large and steady quantity of total output. Six times during the past few years this output has been the greatest, not only in the United Kingdom but in the world. This was the case in 1900, when the construction amounted to 81,794 tons. The next year the construction was 82,262 tons, but was exceeded by one other firm. In 1902 there were constructed 42,254 tons; in 1903, 39,493 tons; in 1904, 57,357 tons; in 1905, nineteen vessels of 63,226 tons, or an average of 3,328 tons each; in 1906, twenty-four vessels of 85,111 tons, or an average of 3,546 tons each.

The several bays are divided from each other by rows of cast iron columns, giving easy communication from one to the next. The outside bays are fitted with galleries throughout the length, while the inside bays have four powerful traveling cranes for the transporting of material from one place to another. Each row of columns supports a line of main shafting, and each line is driven direct by a pair of compound engines fixed on the columns.

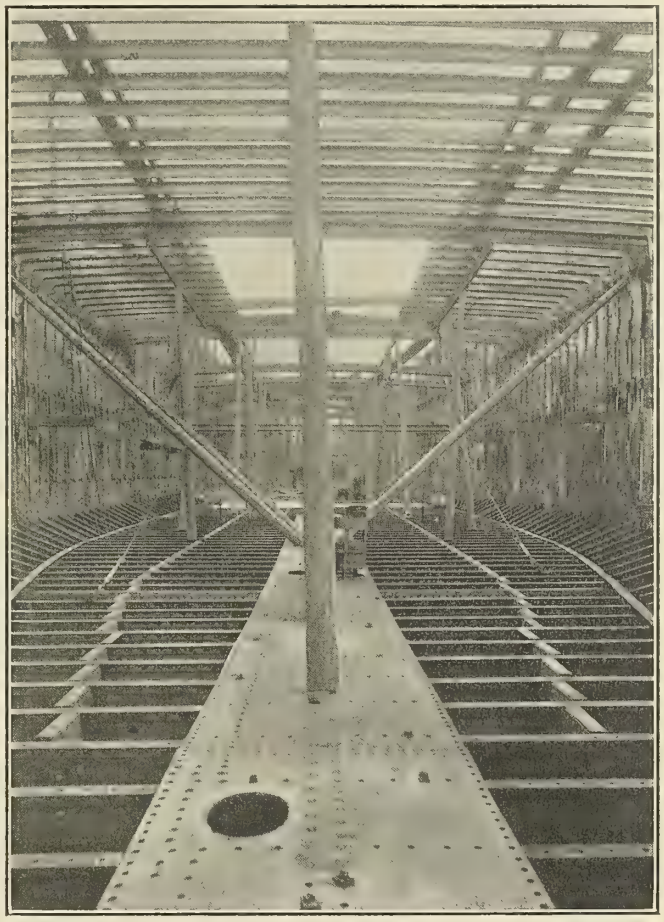
The iron foundry has a width of 63 feet, and is fitted with a traveling crane of a capacity of 40 tons, besides a hydraulic crane of 5 tons rating. At right angles to this loam foundry is

the sand foundry, 320 feet long, and consisting of two spans measuring respectively 53 and 26 feet in width. The larger span is traversed by a crane similar to that in the loam foundry, but lighter in capacity. The foundry cupolas, three in number, are situated in the angle between the two foundries, and are thus readily accessible from each.

The boiler department adjoins the engine works, and comprises two main bays, 300 feet in length and respectively 58 and 53 feet in width. Both bays are traversed by traveling cranes fitted with engines and boilers. The main line of shafting in this department is driven in the same manner as in the engine department. Among the powerful machine tools may be mentioned a very large hydraulic riveting machine, a powerful flanging machine and a plate bending machine capable of bending to a circle plates 12 feet in width and up to a thickness of 2 inches. There is also a circular annealing furnace capable of accommodating the whole shell of a boiler after the work of welding and flanging has been completed.

A specialty in the manufacture of boilers is noticeable in the welding and flanging of the cylindrical shell plates, and the fitting thereto of the flat end plates, which are also welded at the corners of their seams. This method obviates entirely the joggling of one plate over another, thus saving in weight and also from the point of view of calking. The circumferential part of the shell consists of two plates only, the ends for boilers up to 13 feet in diameter being of one plate only, thus making the entire boiler of four plates. The two longitudinal seams of the shell are so placed that there are no seams or rivets under the bottom of the boiler. Owing to the shell plates being flanged to receive the flat end plates, no rivet heads protrude from the bottom at either end. Throughout the boiler shop of this establishment the calking is done by pneumatic means.

In connection with these shops is another bay, measuring 150 by 75 feet, for the accommodation of lighter work, such as tanks, etc., while still another comprises the tool, bar iron and tube storage. The forge and blacksmith department and the pattern shop are in the rear of the main buildings, the former being so placed as to minimize vibration in the main shops, due to the working of the heavy hammers, while the latter are so situated as to avoid as much as possible all risk of fire.



INTERIOR OF SHIP UNDER CONSTRUCTION IN THE GRAY YARD.

The forge includes in its equipment two 5-ton steam hammers, each served by two 15-ton jib cranes. The waste gases from the forge furnaces are utilized to heat the feed water for the boilers. The forge department is entirely self-contained, having all the machine tools necessary for finishing shafting and other forgings ready for fitting in place on the ship. This department turns out all the stern and rudder frames and engine forgings required. A drop hammer plant has lately been added, capable of dealing with forgings up to 112 pounds, thus reducing in large measure the amount of hand labor required and cheapening the cost of production. In connection with this plant liquid fuel furnaces have been adopted for heating material.

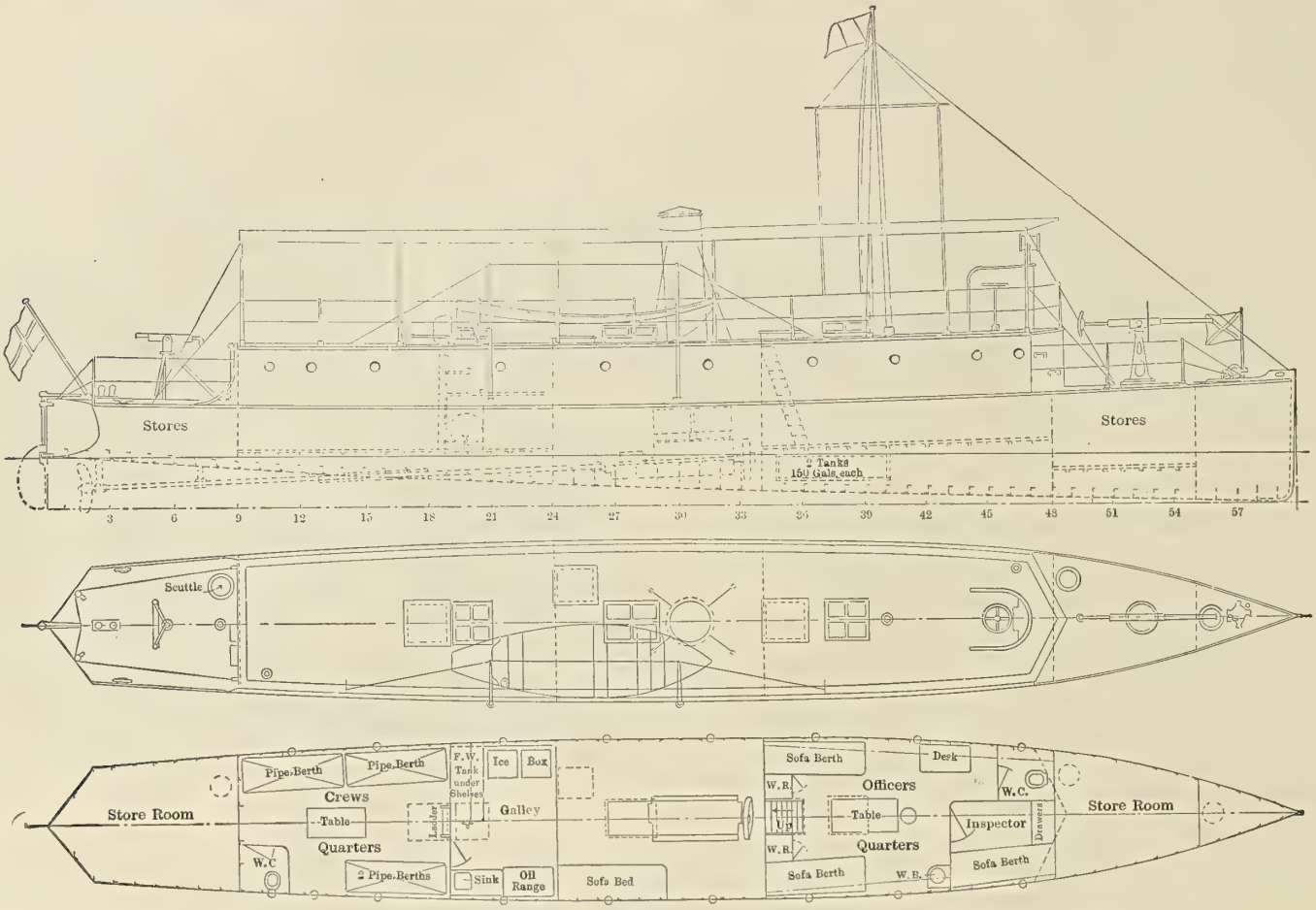
CENTRAL SHIPBUILDING YARD AT WEST HARTLEPOOL.

On the quay in the front of the works is a set of 80-ton sheer legs, and there is a smaller hydraulic jib crane for handling the lighter weights. Hydraulic pumping engines in connection with an accumulator furnish a pressure of 1,000 pounds per square inch. Hydraulic power is carried into all departments, and is utilized in cranes, tools, elevators to the galleries, and in operating the great doors at the ends of the shops.

The steam generating plant is situated close to the main shops, and contains three Galloway boilers, designed for a

working pressure of 205 pounds per square inch, and fitted with Proctor mechanical stokers and Green fuel economizers. These boilers are supplemented by two double-ended Scotch boilers.

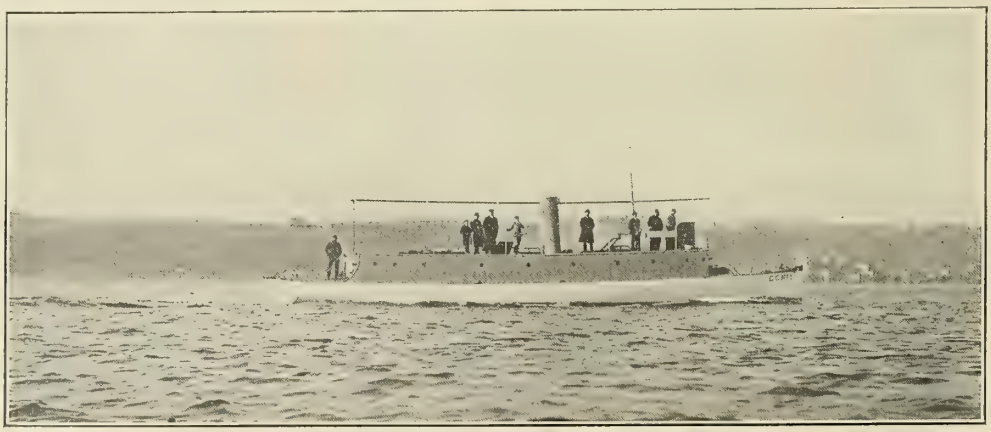
A special feature of the machinery built by this firm is the high fuel economy obtained in many of the constructions. In this connection might be mentioned the steamers *Inchmona, Inchkeith, Inchdune* and *Inchmarlo,* which were described at page 332 of our issue for August, 1901. These steamers are fitted with Mudd 5-crank quadruple expansion engines, the boilers operating under the Ellis & Eaves system of induced draft at 267 pounds per square inch, and being fitted with superheaters. The elaborate provision of fuel-saving apparatus contained in these equipments has brought the fuel consumption down to less than one pound per indicated horsepower per hour. This has worked out, for a ship carrying 6,170 tons dead weight, to 15½ tons per hour at a speed of 9½ knots, or to 13¼ tons at 9 knots. This means that a ton is carried one nautical mile on an expenditure of about ⅓ ounce of coal.



OUTBOARD PROFILE, WEATHER PLAN AND ACCOMMODATIONS OF NEW GASOLINE PROPELLED PATROL LAUNCHES.

New Gasoline Patrol Vessels.

For administering the customs of the Republic of Santo Domingo, and particularly in connection with patrol work to prevent smuggling into that republic, the United states government has recently had constructed at the Perth Amboy yard of Lewis Nixon four vessels, each propelled by a four-cylinder engine built by the Standard Motor Construction Company, of Jersey City.

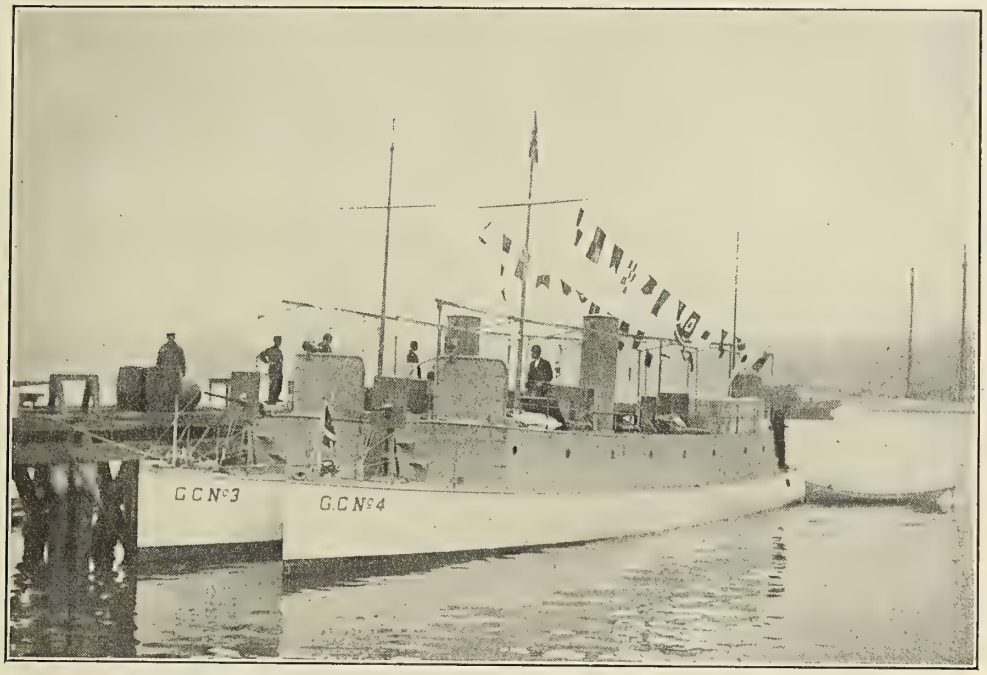


COAST GUARD VESSEL NO. 1 RUNNING ON THE HUDSON RIVER.

These vessels have a length of 75 feet, a beam of 10 feet and a draft of 3 feet 3 inches, and are distinguished by a straight

stem running down almost to the keel, and a flat stern coming flush with the water line, while the after part of the hull is cut off into an obtuse V-shape. The hull is of steel, the frames being angles measuring 1½ by 1⅛ inches, while the plating in general has a thickness of ⅛ inch.

The four boats left New York in December by the outside route, taking three days to reach Charleston, whence they went to Miami, and thence to their destination. They met very severe weather on the trip, but are reported to have behaved splendidly in a seaway.



COAST GUARD VESSELS NO. 3 AND NO. 4, SHOWING THE FORWARD BATTERY OF ONE GUN.

The general lay-out of the vessels is shown in the illustration; there being a store room aft of the collision bulkhead; the next section is taken up by officers' quarters, provision being made for one customs inspector and two officers. Then comes the engine space, with berth for one engineer, aft of which come the galley, the crew's quarters, with berths for four men, and the after store room. The quarters have ample head room, and for the stores the hatches are of considerable size.

The engine, which operates a single screw, has four cylinders, 8 by 10 inches, and develops about 50 horsepower, giving a speed on trial of 12.5 knots. Gasoline is stored in two copper tanks below the waterline, being under the officers' quarters, and holding 150 gallons each. This gives a fuel supply sufficient for 400 nautical miles at a speed of eleven knots, or 1,000 miles at eight knots. A funnel is fitted above the engine room, into which the exhaust is discharged. This creates a very powerful current of air, keeping the engine room cool and fresh in the hottest weather.

Each of the four boats carries forward a one-pounder rapid fire gun, while aft is a Colt automatic gun. A single boat, 16 feet long, is carried by davits amidships on the starboard side. The steering station is located just above the officers' quarters, and consists of a shield, 4 feet high, containing an automobile hand gear. On a platform at the front of this shield is a searchlight projector, while a little to the rear of the shield is a signal mast, with one spar. An awning covers the entire upper deck, which extends from the forward end of the officers' quarters to the after end of the crew's quarters. Skylights are fitted over the officer's quarters, the engine room and the galley, while dead lights on each side give ample light and air to the various compartments. A hand winch forward takes care of the anchor and mooring hawsers, while a bitt aft can be utilized for towing. The rudder is entirely overhung, and is operated by a tiller working above the after deck. The tiller chains are also above the deck. Fresh water is provided by means of a Standard exhaust distilling plant, which utilizes waste heat from the engine for evaporating the water to be used for drinking purposes.

A New Zealand Coasting Steamer.

The twin-screw steamer *Atua,* recently built and engined for the Union Steamship Company of New Zealand, Ltd., by David J. Dunlop & Co., Port Glasgow, is in many respects an interesting vessel. Her principal dimensions are:

Length between perpendiculars	320 ft. 0 in.
Breadth molded	44 ft. 0 in.
Depth molded to main deck	21 ft. 9 in.
Depth molded to upper deck	29 ft. 8½ in.

There are shade decks, amidships and aft, over the passenger accommodation, 8 feet above the upper deck, with a boat deck over the shade deck amidships. Accommodation is provided for about 100 first-class passengers in large airy staterooms on the upper and shade decks amidships, where also are a spacious dining saloon, music saloon, ladies retiring room, and smoking room, all tastefully fitted in polished hardwood. The second-class passengers are accommodated aft in staterooms on the main and upper decks, where are berths for about 50 persons. A large dining saloon, seated for 40, is fitted up in a deckhouse on the upper deck. The greatest care has been exercised in the design and arrangement of all the staterooms to secure the utmost comfort.

The accommodation for the officers has been fitted up in a large teak deckhouse on the boat deck, with charthouse on the flying bridge above; the engineers are accommodated in 'tween decks amidships, and the crew, firemen, etc., in quarters under the forecastle.

All the latest appliances have been adopted for the expeditious working of cargo. The equipment of the steamer includes electric lighting plant, refrigerating machinery, and cooling chambers, Clayton fire extinguishing apparatus, with piping and valves to all compartments, steam steering gear, steam windlass, steam winches, and all the life saving appliances required by the Board of Trade and the New Zealand government.

The machinery consists of two sets of triple expansion engines, having cylinders 21½, 35 and 57 inches in diameter, with a

common stroke of 39 inches, supplied with steam from four single-ended boilers 14 feet 6 inches diameter by 11 feet 6 inches long, all proportioned for working pressure of 180 pounds per square inch. The engine room outfit and gear includes Weir's feed pumps, Drysdale's centrifugal pumps, surface feed heater, evaporator, Howden's forced draft, and ash ejectors. Bronze propeller blades are fitted.

The *Atua* is much larger and of greater power than the *Navua*, built for the same company eighteen months ago by Messrs. Dunlop, and is intended for the same trade as the latter vessel. The *Atua* is classed in the British Corporation for the Survey and Registry of Shipping. B. T.

Torpedo Boat Docks at the Kiel Imperial Ship Yards.

BY DR. ALFRED GRADENWITZ.

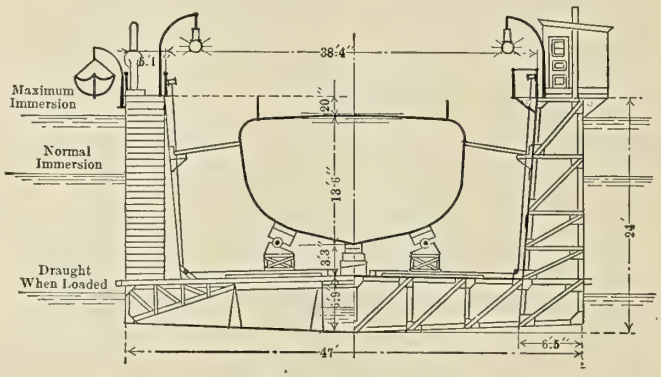
In the construction of docks, the general tendency should be to permit of docking as many different types as possible of the vessels touching at the harbor in question. Floating docks will show the advantage over dry docks, in that the amount of energy expended in lifting is approximately proportional to the size of the ship, whereas, in dry docks a decrease in the size of the ship rather results in a considerably increased amount of energy consumption and working expenses. The docking of small vessels in a dry dock thus becomes extraordinarily expensive as compared with floating docks. Considering all the further advantages afforded by floating docks, viz., the shorter time of construction, considerably shorter time of pumping, smaller cost of construction, simplicity and cheapness of operation, their economy would seem to be so much higher than that of dry docks that it may be wondered at why the construction of the latter is at all continued. Anyhow, floating docks have been adopted to an ever increasing extent of late years, even in cases in which the possibility of utilizing the tide in dry docks would have allowed the pumping work to be either dispensed with or considerably reduced.

4. The pontoons should be of substantial construction and allow of a ready upkeep, Siemens-Martin ingot iron on the regulations issued by the German navy being used as material.

5. The plant should be worked as economically as possible.

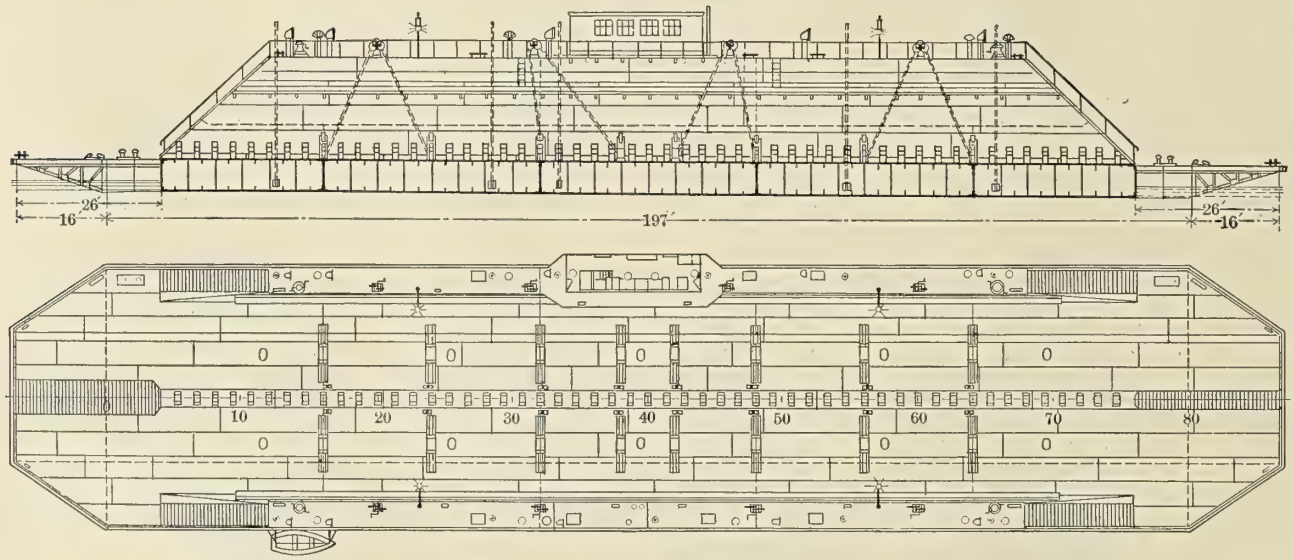
6. The bulkheads, pipes, valves, etc., should be so arranged as to warrant a ready manipulation and a uniform lifting and lowering.

7. The pontoons should be as bright and airy as possible.



SECTION OF DOCK FOR CARRYING TORPEDO BOATS.

Some departures from the usual practice will be observed in the external aspect of this plant, comprising two self-contained docks. In fact, in view of the comparatively great length of the dock, an extension of the supporting pontoons and of the lateral compartments throughout the structure would have resulted in a useless increase of the cost of construction. The pontoon has accordingly been given a length of only 60 meters (197 feet), platforms 5 meters (16 feet 4 inches) in length being arranged on both sides, resting on trussed girders. The latter are of such substantial construction as to permit of ships being repaired from them.



INBOARD PROFILE AND PLAN OF FLOATING DRY-DOCK USED FOR THE REPAIR OF GERMAN TORPEDO BOATS.

An interesting floating dock plant has been recently constructed to the order of the Imperial ship yards, of Kiel, Germany, by the Howaldtswerke, especially for the docking of torpedo boats.

The following requirements had to be met in connection with this plant:

1. The plant should be able simultaneously to dock and to undock several torpedo boats.

2. Both the empty dock and the dock loaded with a 400-ton boat should be lowered and lifted as rapidly as possible, no more than one-half hour being allowed for this operation.

3. The pontoons should be of sufficient stability in all positions, even with a load of 600 tons.

Moreover, wide insets 8 meters (26 feet) in length, penetrating 3 meters (9 feet 10 inches) into the supporting pontoon, have been arranged at both ends, to allow the bow and stern rudders of torpedo boats to be removed. When out of use, these are covered with a timber planking. The shape of the lateral compartments, while satisfying the requirements of stability, affords the possibility of arranging wide staircases, without any loss of useful space, which would have been the case had the staircases been placed on the inner walls. The ready means of access and descent thus insured to the men of the torpedo boats are especially valuable.

In view of the short time allowed for lifting, a special point

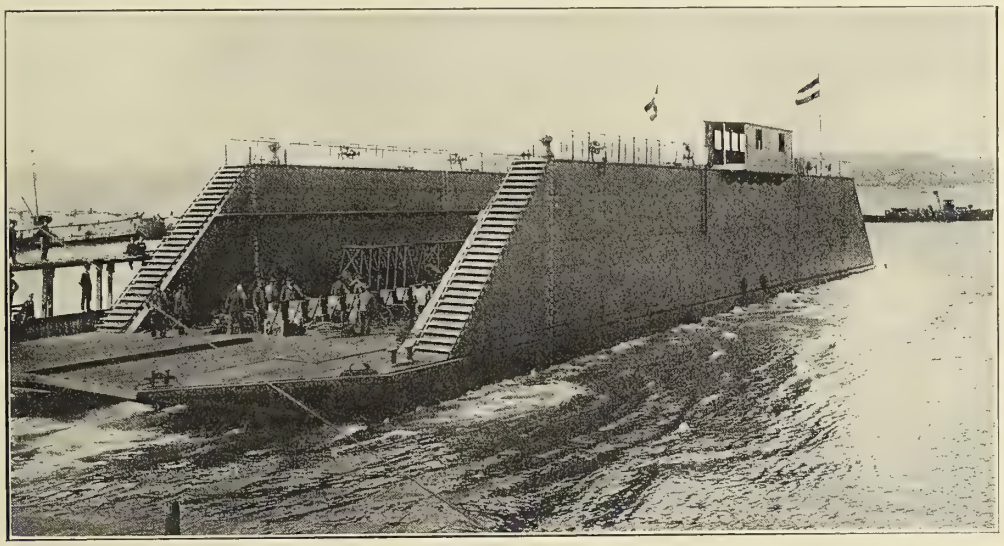
was made of simplifying and accelerating the operation, and increasing its safety. In addition to the division of the dock into twenty compartments, by means of bulkheads, a safety deck has been provided for, thus limiting the extreme depth of immersion, in order to exclude any risk of submersion even in the event of all compartments being filled, by some inadvertency.

Although arranged at intervals of 1.3 meters (4 feet 3 inches), the keel blocks may be placed at any longer or shorter intervals, for which purpose they are fixed to the deck with rotary bows. Bilge blocks moving on carriages, which automatically adapt themselves to the shape of the ship, being removed in the case of repairs, serve as a lateral stay to the ship. These are operated by means of hand winches from the deck of the side compartments, and are so designed as to enable two blocks to be operated, either simultaneously or singly.

Each dock has been provided with two centrifugal pumps, each being operated by means of the same lever and rod. The levers are arranged side by side in two groups of five each in the driver's cabin, where all the operations for lifting and lowering the dock are performed.

The dock is filled and emptied by the common conduit, by first opening the two main admission valves, after which the water entering the main conduit is distributed into the various compartments by the regulating valve. In emptying the water, the inlet valves being locked, the pumps are set working, after which the valves of the pressure pipes of the pumps are opened, and a uniform discharge of each of the compartments is effected by the aid of the regulating valve. The level in each of the compartments is indicated by floats, and can likewise be observed from the driver's cabin.

The dock is lighted by four arc lamps and a number of incandescent lamps.



THE LAUNCHING OF A FLOATING DOCK FOR HANDLING TORPEDO BOATS.

of which is directly operated by a 25-horsepower alternating current motor, in addition to a duplex pump, which is likewise driven by electricity, and which is used in washing the deck, for fire-extinguishing purposes, as also in freeing the dock from any surplus water, which, however, owing to the efficiency of the main pumps, will in most cases be found quite unnecessary.

A power station situated on land is used to supply current at 110 volts and 100 cycles. The motors are installed above the safety deck, immediately below the driver's cabin, being connected by vertical shafts to the centrifugal pumps fixed in the lower pontoon. They work at a speed of 580 revolutions per minute, whereas the motor of the duplex pump runs at 960 revolutions per minute, driving the pump through gearing.

The pressure pipes of the centrifugal pump are fitted with locking valves 375 millimeters (14.8 inches) in diameter, and are so arranged that the exhaust is placed above the level of the water in the raised dock. Main conduits 375 millimeters in diameter lead from each pump to the pontoon, these two conduits being so connected with each other by a pipe as to allow of both sides being served by one pump. The connecting pipe, 275 millimeters (11 inches) in diameter, is closed by a valve operated from the power station like the valves in the two main conduits. Branch conduits 170 millimeters (6.7 inches) in diameter lead from the main conduit to each of the sections of the dock, one to the middle of the dock and one to the lateral bulkhead. The latter conduits are provided with internal reflex valves, so that all the pipes may be used in filling, while only those leading to the middle of the dock are available for suction, thus leaving a minimum of residual water in the pump. Each pipe is fitted with a regulating valve, the valve of the pipe leading to the middle of the pontoon and that of the corresponding lateral pipe

The main dimensions of the dock are as follows:

	Meters.	Feet.
Total length	70.00	230
Lower clear width 1.5 meters (4 feet 11 inches) above floor of the deck	11.00	36
Upper clear width	11.70	38.3
Lower length of a side compartment	54.00	177
Upper length of a side compartment	42.00	138
Lower width of a side compartment	1.80	5.9
Upper width of a side compartment	1.225	4
External width of iron structure	14.35	47
Central height of pontoon	1.80	5.9
Length of bearing pontoon	60.00	197
Draft in loaded condition	1.55	5.1
Draft lowered (extreme)	7.00	23
Lowering above keel blocks (extreme)	4.20	13.8
Height of keel blocks	1.00	3.3
Height of dock body from lower edge of dock to the deck of side compartment	7.50	24.6

Steamship Lines to Brazil.

The growing competition between rival German and English steamship lines plying between Europe and Brazil, and touching at Madeira, has resulted in the announcement of a new 10,000-ton steamer for the Hamburg-American Line, and three new steamers of 6,000 tons each, now rapidly approaching completion, for the Woermann Line. It is stated that this increase in tonnage has been made by the German companies in opposition to the Royal Mail Steamship Company, recent additions to the fleet of which have forced competitors to duplicate the comforts and conveniences presented by the English line.

Lloyd's Annual Summary of Shipbuilding.

The report made by Lloyd's Register of British and Foreign Shipping for the year 1906 covers all vessels of upwards of 100 tons which were launched in 1906. The total of merchant vessels for the entire world is given as 1,836, amounting to 2,919,263 gross tons, or an average of 1,588. Of this total, 1,457 steamers account for 2,794,046 gross tons, or an average of 1,920 tons each; while 379 sailing vessels show an aggregate of only 125,717 tons, or an average of 331 each. Of the total, 886 vessels, amounting to 1,828,343 gross tons, are accredited to the shipbuilders of the United Kingdom, the average size being 2,062 tons. The construction outside of the United Kingdom amounted to 950 vessels, aggregating 1,091,420 tons, or an average of 1,150 tons. One feature of the construction that is interesting is that more than 80 percent of the sail tonnage was built outside of the United Kingdom, while about 65 percent of the steam tonnage was built in the United Kingdom. The sail tonnage of the United Kingdom was only about one percent of the total tonnage launched, while for outside countries it was almost 10 percent.

	1892-'96.	1897-'01.	1902-'06.
United Kingdom	5,103,559	6,704,057	7,274,849
British Colonies	65,189	83,613	131,314
United States	425,708	1,251,128	1,743,426
Germany	435,838	926,883	1,174,305
France	130,617	500,696	474,547
Holland	51,764	149,204	294,855
Italy	42,292	216,960	218,564
Japan	14,450	66,690	168,878
Norway	83,225	137,397	243,300
Other Countries	141,724	232,079	346,968
Totals	6,494,366	10,268,707	12,071,006
British percentage	79.7	66.0	61.4
American "	6.55	12.2	14.4

Year.	Totals.		United Kingdom.		France.		Germany.		Holland.		United States.	
	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.	No.	Tons.
1892	1,051	1,358,045	681	1,109,950	19	17,228	73	64,888	15	14,368	73	62,588
1893	846	1,026,741	536	836,383	22	20,337	65	60,167	8	1,339	36	27,174
1894	932	1,323,538	614	1,046,508	28	19,636	77	119,702	41	15,360	43	66,894
1895	880	1,218,160	579	950,967	27	28,851	75	87,786	25	8,292	61	84,877
1896	1,113	1,567,882	696	1,159,751	41	44,565	63	103,295	28	12,405	144	184,175
1897	990	1,331,924	591	952,486	39	49,341	84	139,728	42	20,351	84	86,838
1898	1,290	1,893,343	761	1,367,570	48	67,160	104	153,147	27	19,468	162	173,250
1899	1,269	2,121,738	726	1,416,791	51	89,794	93	211,684	50	34,384	148	224,278
1900	1,364	2,304,163	692	1,442,471	66	116,858	93	204,731	61	45,074	235	333,527
1901	1,538	2,617,539	639	1,524,739	92	177,543	101	217,593	33	29,927	286	433,235
1902	1,650	2,502,755	694	1,427,558	99	192,196	108	213,961	114	69,101	251	379,174
1903	1,650	2,145,631	697	1,190,618	75	92,768	120	184,494	109	59,174	246	381,820
1904	1,643	1,987,935	712	1,205,162	69	81,245	149	202,197	109	55,636	227	238,518
1905	1,576	2,514,922	795	1,623,168	43	73,124	148	255,423	58	44,135	200	302,827
1906	1,836	2,919,763	886	1,828,343	48	35,214	205	318,230	89	66,809	242	441,087

The warships launched in the United Kingdom aggregated 29, with a total of 108,450 tons displacement, or an average of 3,740. Warships launched outside the United Kingdom aggregated 119, of a total displacement of 254,522 tons, or an average of 2,138. The total warship construction amounted to 148 vessels, aggregating 362,972 tons, or an average of 2,451 tons.

The grand total of all construction thus amounts to 1,984 vessels, aggregating 3,282,735 tons, or an average of 1,656. Of this total, the United Kingdom is credited with 915 vessels, aggregating 1,936,783 tons, or an average of 2,118; while the rest of the world constructed 1,069 vessels, amounting to 1,345,942 tons, or an average of 1,260.

The construction of merchant ships, during the fifteen calendar years from 1892 to 1906 inclusive, is shown in the table. It will be seen that, except for an occasional falling off, the progress has been continually towards larger construction with each successive year.

Due to local or temporary reasons, it is not always fair to compare any one year with any other one year, but when a series of years is taken, a fair showing can be obtained. With this idea in view, we have grouped construction in the fifteen years mentioned into three periods, each containing five years, and show the results in another table, in which the progress of shipbuilding is more clearly outlined than in the first.

The merchant shipbuilding for 1906, outside the United Kingdom, includes 242 vessels in the United States, aggregating 441,087 tons, or an average of 1,822; 205 vessels in Germany, aggregating 318,230 tons, or an average of 1,551 tons; 89 vessels in Holland, aggregating 66,809 tons, or an average of 751; 69 vessels in Norway, aggregating 60,774 tons, or an average of 891; 107 vessels in Japan, aggregating 42,489 tons, or an average of 397; 48 vessels in France, of an aggregate of 35,214 tons, or an average of 733; 30 vessels in Italy, aggregating 30,560 tons, or an average of 1,019; 57 vessels in the British Colonies, aggregating 26,042 tons, or an average of 459; 18 vessels in Denmark, aggregating 24,712 tons, or an average of 1,372; 25 vessels in Austria, aggregating 18,590 tons, or an average of 744; and 60 vessels in other countries, aggregating 26,913 tons, or an average of 449.

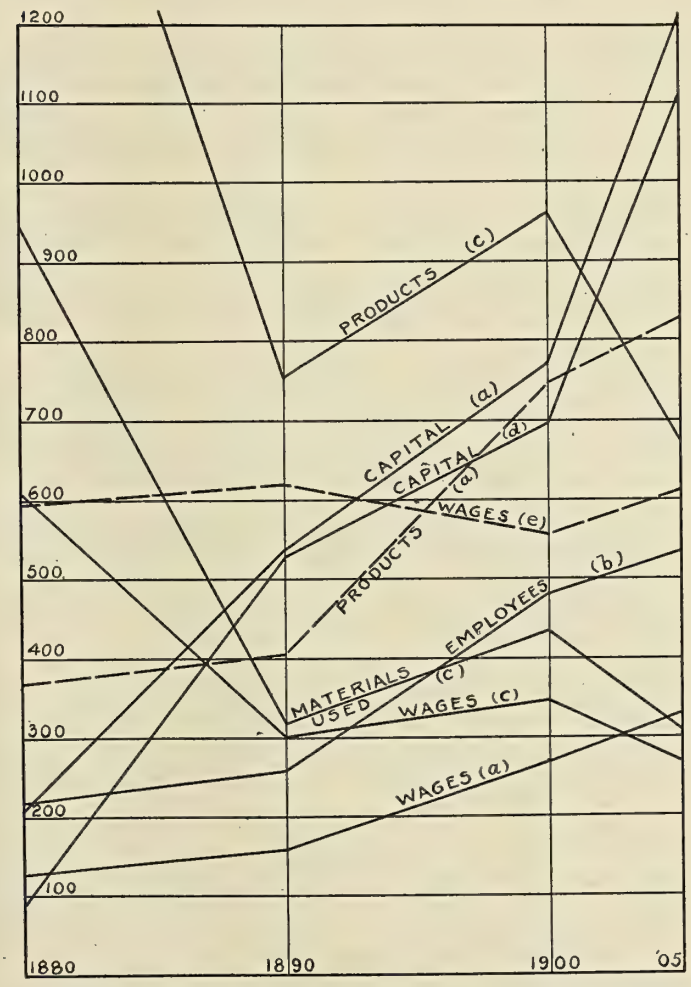
The merchant tonnage for the United Kingdom is a record breaker, being 205,000 tons greater than in 1905; 304,000 tons greater than in 1901, and 386,000 tons greater than in 1900, which were the largest previous years. In the United States, the figures are the largest on record, being 8,000 tons greater than in 1901 and 60,000 tons greater than in 1902 and 1903. The German tonnage is also the greatest ever constructed, being 63,000 tons ahead of 1905 and 101,000 tons in advance of 1901. Dutch construction is 2,300 tons less than in 1902. Norwegian construction is a record, being 8,200 tons ahead of 1905 and 10,300 tons more than 1904. Japanese construction is another record, being 5,300 tons ahead of 1901 and 8,000 tons ahead of 1903. French construction is the smallest since 1895, being less than one-fifth the construction of 1901 or 1902, and less than one-half the construction of 1903, 1904 or 1905. Italian construction is less than one-half of 1905 or 1900, and but slightly more than one-half of 1901. The construction in the British Colonies is less than in 1901, 1902, 1903 and 1904. Danish construction is less than in 1899, 1902 and 1903. Austrian construction is larger than in any previous year except 1901.

Census of Shipbuilding.

A recent census bulletin covers the shipbuilding industry of the United States in tabular form, including the building and repairing of all classes of water craft, iron, steel and wooden vessels, yachts, boats, barges and scows, irrespective of their uses or the classes of traffic in which they are employed. These tables separate the shipbuilding into two general classes of wooden shipbuilding, and shipbuilding in iron and steel.

Under the latter heading the total cost of materials used is shown to have increased between 1900 and 1905 from $23,586,000 to $27,602,000, or 17 percent. The product increased during this period from a value of $50,368,000 to $58,433,000, or 16 percent. Included in the product is under each year somewhat more than $12,000,000 worth of repair work. The number of vessels launched during the year increased from 134 in 1900 to 156 in 1905. The gross tonnage increased from 262,516 to 330,551, or 26 percent. The net tonnage increased from 186,509 to 217,284, or 16.5 percent. The average size of vessel in 1900 was 1,960 gross tons, and in 1905 the average size was 2,120 tons. The average net tonnage in 1900 was 1,390 tons; while in 1905 it was 1,393 tons.

The value of the vessels constructed in 1900 amounted to $25,455,000, or an average of $190,400 each. The average cost per gross ton was about $97; per net ton, $137. In 1905 the total value, including contract price of finished vessels, aggregated $63,690,000, this figure covering a large amount of work not done during the census year, and therefore not included in the total value of products during that year. The average cost of the vessels included in this figure is seen to be $408,000. The average value for each gross ton figures out at $192; for each net ton, $293. It is extremely doubtful if any reliance can be placed upon the figures here given for gross and net tonnages as comparing the two years. Although the report does not so state, it is without question a fact that the figures are not strictly comparable, those for the one year being evidently compiled upon a basis different from that used during the other year.



HISTORICAL DEVELOPMENT OF SHIPBUILDING IN THE UNITED STATES.
(*a*) = Totals in units of $100,000. (*b*) = Hundreds. (*c*) = Dollars per $1,000 capital. (*d*) = Per establishment, in units of $100. (*e*) = Dollars per man.

Wooden shipbuilding shows a decrease in cost of materials used from $9,889,000 in 1900 to $9,861,000 in 1905. The total value of products shows a slight increase, the figure for 1900 being $24,165,000, and for the year 1905, $24,336,000. Included in this total is repair work, which amounts each year to between $10,000,000 and $11,000,000. The number of vessels of five tons and over launched during the year aggregated 1,947 in 1900, and 2,093 in 1905. The gross and net tonnages in 1900 were 424,643 and 355,815 respectively; in 1905 they were 372,033 and 342,085. In each year the amount of work on steam and power vessels aggregated about $3,000,000; on sailing vessels about $3,300,000; on barges about $3,500,000.

Another table in the report shows that the number of establishments engaged in shipbuilding decreased from 2,188 in 1880, to 1,010 in 1890, 1,107 in 1900, and 1,097 in 1905. The total capital has shown a continuous increase from $21,000,000 in 1880, to $53,000,000 in 1890; $77,000,000 in 1900, and $122,000,000 in 1905. The total number of employees has increased from 21,345 in 1880, to 26,000 in 1890; 48,000 in 1900, and 53,000 in 1905. The table shows the general relation in each of these four years between capital, product, employees and wages.

	1880.	1890.	1900.	1905.
Establishments	2,188	1,010	1,107	1,097
Capital*	$20,980	$53,393	$77,341	$121,624
increase in period..	.....	107%	45%	57%
per establishment...	$9,580	$52,850	$69,800	$110,850
Employees	21,345	25,934	48,152	53,234
increase in period..	.....	21½%	86%	10½%
per establishment...	10	26	44	48
Wages, total*.....	$12,714	$16,029	$26,832	$32,581
increase in period..	.....	26%	67%	21%
per establishment..	$5,810	$15,870	$24,240	$29,700
per employe	$596	$618	$557	$612
increase in period.	.....	3.7%	—9.9%	9.9%
Products, value*.....	$36,800	$40,342	$74,532	$82,769
increase in period..	.....	9½%	84%	11%
per establishment..	$16,800	$39,950	$67,300	$75,400
increase in period	.....	138%	68%	12%
per employe.....	$1,723	$1,555	$1,548	$1,555
Cost of materials*...	$19,736	$16,925	$33,475	$37,463
Per $1,000 capital:				
Materials used....	$942	$317	$433	$308
Value of product..	$1,754	$757	$961	$681
Total wages.....	$606	$301	$347	$268
Ratio:				
Materials to product	0.536	0.419	0.449	0.453

* In thousands of dollars.

International Maritime Exposition.

In celebration of a century of steam navigation an exposition will be held by the League Maritime Française, in the city of Bordeaux, from May to November, 1907. The exposition will be under the official patronage and aid of the French government, of the Department of the Gironde, the city of Bordeaux, the Chamber of Commerce and the Philomathic Society. It is open to citizens of all countries, and will receive exhibits of all industrial, agricultural or artistic products pertaining to maritime affairs. Sections will be devoted to ocean geography, aerial navigation and motor boats. It is the intention to include congresses, competitions and lectures on subjects concerning maritime affairs.

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The edition of this issue comprises 6,000 copies. We have no free list, accept no return copies and issue only enough to supply the regular demand.

Of Interest to the Antiquarian.

This number completes ten years of publication of this periodical. The beginning was small, but expansion has come with age, and to-day we can look with satisfaction on a clientele of subscribers and advertisers, of large proportions, and of such a character as to mutely attest to the esteem in which the publication is held, both at home and abroad.

We entered the field when the annual merchant shipbuilding of the world amounted to less than half what it does at the present time, and when that of the United States was only one-fifth of the present figures. Throughout this space of time we have been actuated by the determination to give to our readers as nearly as possible a concise account of the trend of shipbuilding, ship design and marine engineering matters generally, with details of as many structures of varied types and sizes as could be conveniently placed within the limits of our pages. We believe that we have succeeded in this endeavor to a very gratifying extent, though we realize that in many cases fulfilment has fallen far short of desire. The task is not always an easy one. Professional secrets form a large stumbling block, while rush of work in engineering and shipbuilding offices accounts in large measure for our inability to obtain at first hand authoritative descriptions which we would like to make public through our columns. In many cases, we have been able to circumvent or otherwise neutralize the restrictions thus placed upon us, but sometimes it has been impossible to do this, and notable constructions have been allowed to pass unnoticed, because of the difficulty in obtaining satisfactory material for a notice.

We are entering upon the second decade of our existence with a standing all over the world which we think and hope will enable us to obtain much of the material which would be withheld from a publication less robust in the character of its contents, and shall continue in our endeavor to place monthly before our readers descriptions of the very best and latest practice in all branches of the twin sciences of naval architecture and marine engineering, to the promotion of which sciences all over the world we are devoted.

International Co-operation.

Cases have been frequent in history where two or more nations have joined forces in warlike exploits. It is probable that the cases in which nations have joined hands in operations other than military far outnumber the latter, but they have in general been of much smaller magnitude, and less has been publicly known about them. A notable instance of the latter type of international co-operation is involved in the construction of the new American life-saving revenue cutter, which we described last month.

The northwestern coast of the United States is very subject to severe weather, particularly in the neighborhood of the extreme northwestern point, which is known as Cape Flattery. Instances are on record where sailing vessels have had to beat about for weeks off this cape before being able to enter the sound, and very many wrecks have occurred, some on the cape, but most of them farther north, on Vancouver Island, which is Canadian territory. In some instances the wrecks have been those of steamers; and in many cases loss of life has resulted. To offset as much as may be the dangerous character of this coast, due largely to the prevalence of heavy winds, the United States is building the revenue cutter in question, and the Canadian government is establishing along the western coast of Vancouver Island a number of signal stations fitted with apparatus for wireless telegraphy.

Just back of the extreme point of Cape Flattery is a small harbor known as Neah Bay, which will form a secure anchorage for the cutter. Being equipped with wireless telegraph outfit, she will be in direct communication with the Canadian stations, and, as soon as any vessel in distress is sighted, the revenue cutter can start immediately to her relief. In many cases this form of co-operation will doubtless result in the saving (by towing) of ships which would otherwise go to pieces upon the rocky coast; while in other cases, where it may prove impossible to prevent the ship from going to her destruction, lives may be saved much more easily than if reliance were placed entirely upon apparatus operated from the land. The character of the coast is one which would make the ordinary form of life-saving exceedingly difficult, cliffs at the water's edge rising in many places to a

height of more than one hundred feet; hence the value of the revenue cutter in this connection.

It will be noted that the major part of the expense of this joint establishment is carried by the United States. To offset this, it may be said that a large proportion of the vessels using the waters to be patrolled belong also to the United States, and that this is particularly true with regard to the great numbers of small vessels propelled by sails, which ply around the northwestern borders of the republic. It goes without saying that this co-operation will be most heartily carried out by both governments, and that both peoples will benefit in large measure from the results.

Cost of Battleship Construction.

A report from Washington states that the total cost of the battleship *Connecticut,* which was built in the Brooklyn navy yard, was $6,340,247 (£1,302,900), while the cost of the sister ship, *Louisiana,* built at the same time by the Newport News Shipbuilding & Dry Dock Company, was $5,980,822 (£1,229,000). This makes an apparent difference of $359,425 (£73,900). It is stated, however, that this difference should really be placed greater than this, because of the fact that the turrets on the *Louisiana* were more expensive to construct than those on the *Connecticut,* and the addition of thirty-five tons of armor to the former involves another item of expense, the aggregate of these two being $30,855 (£6,340). This makes the total difference in cost as between two perfectly similar structures, $390,280 (£80,240).

The *Louisiana* was built under contract dated October 15, 1902, and the order for the construction of the *Connecticut* was given at about the same time. The keel of the *Louisiana* was laid February 7, 1903; that of the other ship, March 10, 1903. The *Louisiana* was launched August 27, 1904; the *Connecticut,* September 29, 1904. The *Louisiana* was first placed in commission June 2, 1906; the *Connecticut,* September 29, 1906. It would thus appear that the *Connecticut* took about four months longer to construct after the placing of the order than did the *Louisiana,* which is another large item in favor of construction in the private plant. The total construction period, beginning with the signature to the contract, appears to have been three years seven and one-half months for the *Louisiana,* and three years eleven and one-half months for her sister ship.

So far as the costs are concerned, it is interesting to note that the battleships *Indiana* and *Massachusetts,* built by William Cramp & Sons, of Philadelphia, under contract dated in November, 1890, cost almost identically the same amount as did the two ships now mentioned. The early ships had a displacement of 10,288 tons, as compared with 16,000 tons in the two now under discussion, which shows an increase of about 52 percent in displacement, without any increase in total cost of construction of ship, machinery, armor, guns and equipment. This result is extremely gratifying to the government, representing as it does a tremendously increased efficiency of product for every dollar spent upon it. The new ships have a speed of about two and one-half knots greater than their smaller prototypes, while the battery has probably double the efficiency of that of the earlier vessels. The armor belt is not so thick in the later ships, but the material of which it is made is sufficiently better in quality to neutralize the difference in thickness, while the area of the ship's side covered by armor is very much greater, and the efficiency of the distribution of this armor is much enhanced.

It would appear from the figures given that the final cost per ton of displacement of the *Connecticut* or *Louisiana* is a little under $400 (£80), while the cost of each ton in the earlier ships was in the neighborhood of $600 (£120).

Marine Disasters.

Another horror has been added to the disasters occurring in connection with the navigation of ships in narrow waters. The steamer *Larchmont,* bound from Providence, R. I., to New York, was run into by a schooner scudding before a heavy gale, and as a result about 150 lives have been lost.

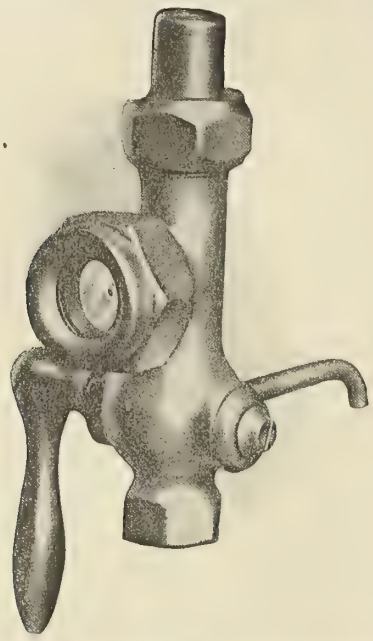
The *Larchmont* represents a type of coasting vessel of which large numbers are extant upon the eastern coast of the United States. The ship was built of wood in 1885, and does not appear to have had any effective watertight bulkheads. It is probable that there was a collision bulkhead in the bow, but this, of course, would be of no avail in connection with a collision such as that which was sustained—that is, ramming amidships by another vessel. There are many steamers of no better construction, threading the waters of the eastern coast, and in summer heavily loaded with passengers. Occasionally a disaster of the character here mentioned, or one even worse, such as that which overtook the *General Slocum* three years ago, calls attention to the antiquated design and construction of these vessels, and to the utterly inadequate facilities provided for withstanding the action of either fire or water. The theory seems to be that there will be no accident which will have to be met, and the vessels are run, year in and year out, upon this assumption. This being the case, the wonder is, not that such accidents do occur, but that they do not occur more frequently. It is safe to assume that they will continue, just as long as an antiquated series of laws governing the construction and operation of such vessels remains on the statute books of a great nation.

There are unnumbered scores of such vessels operating with passenger licenses, and all in imminent danger of some such accident as overtook the two here mentioned. Not one of these vessels should be permitted to carry on her business, with her cargo of human lives, without the provision of effective means for fighting fire, and sufficient facilities for escaping from the vessel in the event of a collision or other wreck.

ENGINEERING SPECIALTIES.

The Multiplus Sight Feed.

The Multiplus sight feed has just been put on the market, and is furnished free with all new improved Rochester automatic lubricators. It is a combination sight feed and three-way cock, with all the advantages of the sight feed, which enables the



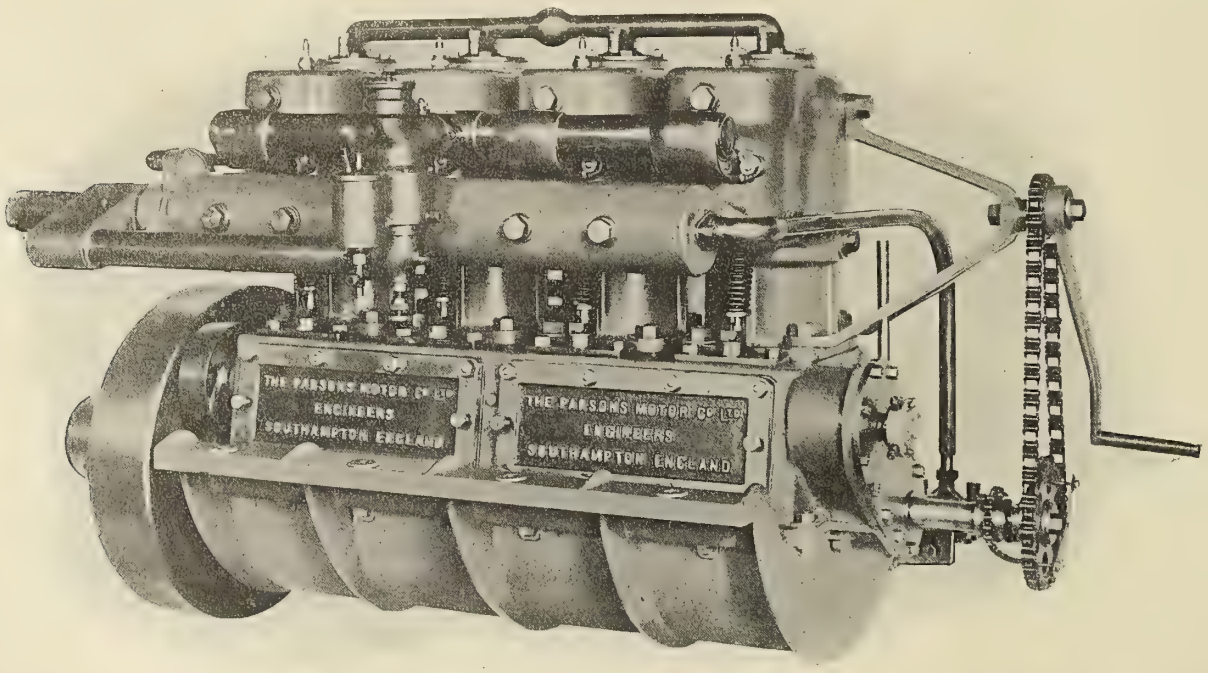
engineer to see at a glance whether or not oil is being pumped to the cylinder or point of delivery, and the certainty of the three-way cock, by means of which the exact amount of oil being fed can be determined, by simply turning the handle. The device is simple in construction, being composed of a chamber, one side of which is a heavy glass disk, against which presses a hollow plunger. In order to pass from the lubricator to the point of delivery the oil must be forced through this plunger, which has an opening in the end. The oil, in forcing its way between the glass and the end of the plunger, moves the plunger back so that only the oil is seen behind the glass, but as soon as the pressure is relieved the plunger resumes its normal position, and the light color of the brass is seen, instead of the dark oil.

It will thus be seen that, when the oil is being fed, the sight feed will keep up a continual "winking." There is always a solid column of oil under pressure, which gives it an advantage over glycerine and water sight feeds. The manufacturers are Greene, Tweed & Co., New York.

The Parsons Marine Engine.

Installed in the 240-ton schooner *Elizabeth,* owned by M. Rochereau, is a 60-70-horsepower engine, right forward. It drives a two-bladed propeller feathering ahead and astern, and also dead fore-and-aft for sailing, through a shaft about 40 feet long. The engine room is equipped with the usual accessories, and there are three fuel tanks, of about 300 gallons capacity, any of which can be connected to the carbureter of the engine. One of these tanks usually contains petrol (gasoline) and the other two paraffin (kerosene), but all three may contain either fuel, as desired by the owner. In the event of paraffin only being carried, the starting of the engine is effected by a little petrol in the carbureter, used from a screw-stoppered can. Once started (which can generally be done by switching on the current) the engine is controlled in all respects as a petrol engine would be. The ignition consists of the usual battery and coil, but with the addition of a small low tension dynamo driven from the cam shaft, which keeps the battery charged at all times. The exhaust branch is taken to a silencer (muffler) fitted in the ventilation up-take.

The water circulation is by a cog wheel pump driven from the engine crank shaft in the usual way. The clutch is of the metal to metal cone type, running in oil. The valve gear is of the compound type, one valve within the other. There is therefore no lamp and vaporizer at all, as is usual with paraffin engines. The propeller in this case has been made by the Gaines



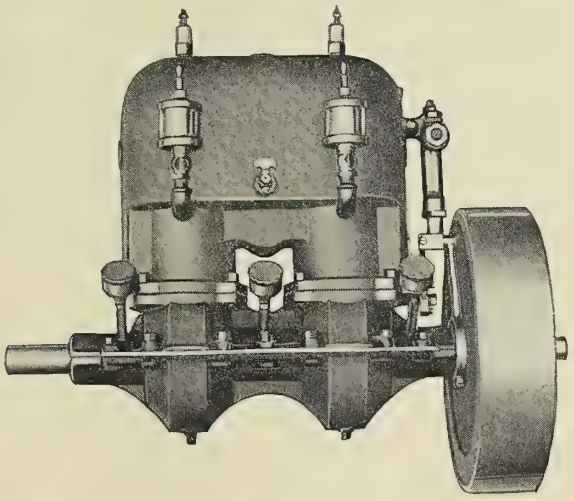
Propeller Company, Ltd., and the shaft is carried in several bearings. The operating gear consists of a worm and rack, and is fixed close to the engine, for facility of control. The timing and the throttle which control the engine are arranged close at hand. Both the engine and the bearing foundations are very solid, and there is practically no vibration in the vessel from the four-cylinder engine. The speed attained on trial was about 5¾ knots.

The engine was built by The Parsons Motor Company, Ltd., Southampton.

A Two-Cycle Gasoline Engine.

The cylinder and head of the Kowalsky two-cycle engine are cast in one piece, thus doing away with all joints where water might leak through and cause trouble. The pistons are fitted with three rings, and are made as light as duty will allow. The third ring in the lower part of the piston is used to prevent the escape of the charge through the exhaust port if the piston should become worn after long use. The center crank bearings are hardened, as well as all bolts and screws used on the engine.

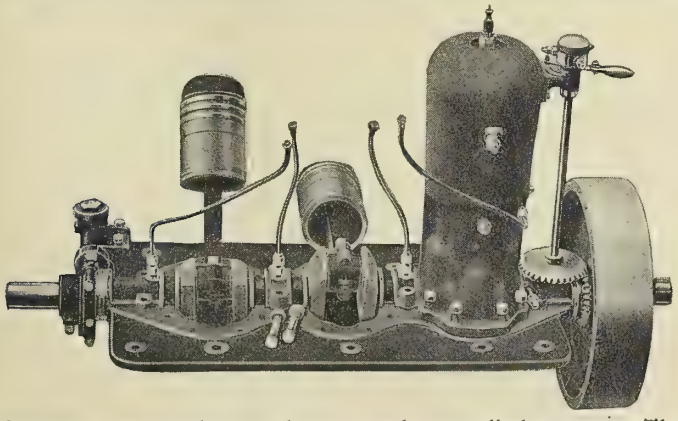
A small but efficient pump keeps up a uniform supply of water, so that there is no chance of the cylinder becoming too hot. The



pump is so fitted that water can be pumped out of boat, as well as from the outside, if necessary. The ignition is by jump spark, with vibrator coil and spark plug. The carbureter used has proved that it will work successfully under all conditions. The speed can be controlled either by throttling or by the spark, or both. Another feature worthy of notice is the fact that this engine will run in either direction, with equal power, and that it can be reversed while running. The main bearings are supplied with compression grease cups, sight feed oiler being used for the cylinder and crank case. The coupling for the propeller shaft is provided with a ball bearing thrust, which is placed between the coupling and the bearing on engine. This engine is placed on the market by the Kowalsky Engine Company, Verona, Pa.

Ferro Auto-Marine Engines.

The new Ferro auto-marine engines, built by the Ferro Machine & Foundry Co., Cleveland, Ohio, are made with one, two or three cylinders, and in sizes from 1½ to 25 horsepower. The illustration shows a three-cylinder engine, which has exactly



the same construction as the one and two-cylinder types. The cylinders are of the "Individual" type, with a flare increasing from the bottom up; are independent of and carry no shaft bearings; have no joints under pressure; no water pipes whatsoever nor visible external connections.

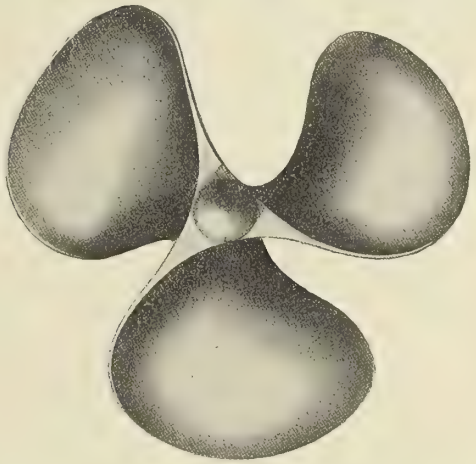
The connecting rods are forged from solid open hearth high carbon steel, especially treated at the fire to develop maximum strength and toughness. There is no bearing at upper end of connecting rod, the hollow piston pin being rigidly clamped so as to rock with it, thereby giving twice the strength and double the bearing surface. The crank pin bearing cap at lower end is adjustable, no lock nuts being used, but instead the Ferro wire seal, which cannot loosen.

The quick starting carbureter is designed strictly for marine service and conditions. The carbureter is shown attached to inlet header, which is of heavy iron, to absorb enough heat to remain slightly warm, insuring uniform temperature of mixture. With all except the smallest size engine, an exhaust silencer is supplied, consisting of exhaust header and condenser silencer combined, obviating the use of a muffler, with its hot pipes.

The Truss Patent Propeller.

By the Truss patent method of eliminating coarse angular pitch of the blades near the boss, the resistance to rotation is said to be so diminished that from 30 to 50 percent less power will have to be expended on rotation only; and the power so saved from reduced resistance to rotation may be expended:

1. In giving a higher number of revolutions to helicoidal bladed screw of pitch, diameter, and area equal to the ordinary screw with radial blades and a higher speed of hull.



2. The screw with the helicoidal blades, if of the same diameter and pitch, may have the width of the blades very much increased without the revolutions of the engines and the maximum power of the engines being increased or reduced thereby, and such increased area of the blades and eliminated angular area near the boss would lead to a considerable increase in the maximum speed of the ship, and large reduction in the number of revolutions required per minute to obtain any required speed.

3. For very long ships of fine lines these helicoidal blades may have the same diameter and total area as ordinary blades, but a higher pitch-ratio, in order to obtain high speed of hull with a moderate number of revolutions per minute. If in this case it were found that insufficient revolutions, horsepower, and speed were obtained, the question whether the pitch ought to be reduced, or the blades reduced in diameter, must be ascertained from calculations made on the results obtained from that particular ship and propeller.

It is claimed that by eliminating the coarse angular area near the boss, a propeller may be of considerable smaller diameter, but still retain its maximum effectual area for propulsion. This again is an advantage, whereby considerably less power is required to obtain a higher speed of hull. The propeller is placed upon the market by T. F. J. Truss & Co., 60 Mark Lane, London, E. C.

TECHNICAL PUBLICATIONS.

The Shipbuilding Industry. By David Pollock, M. I. N. A. Size 7½ by 5 inches. Pages, 199; illustrations, 20. Methuen & Co., London. Price, *2s 6d*, net.

This is one of the series of "Books on Business," and is an excellent manual, thoroughly up to date and full of interest, giving a very readable and comprehensive account of shipbuilding and marine engineering from the historical, practical, scientific and financial standpoints. The sections upon the development of the modern steamship, shipbuilding in up-to-date yards and evolution in structure and types of ships, we found particularly well written. The book is excellently illustrated from photographs.

Notes on Construction in Mild Steel. By Henry Fidler. M. I. C. E. Size, 5¾ by 9¼ inches. Pages, 448; figures, 425. New York and London, Longmans, Green & Company, 1907. Price, $5.

In the collection of notes forming the contents of this volume no attempt has been made to treat the subject from the point of view of applied mechanics, nor are any theories or calculations involved except in so far as they would be required incidentally in connection with the subject matter discussed. The work is arranged for the use of junior draftsmen in the architectural and engineering professions, and the collection of tables and illustrations of various parts treated, and methods of construction, is unusually complete. The work is divided into seven chapters, covering respectively: The manufacture and physical qualities of mild steel; the mechanical elements and the uses of rolled sections in steel; remarks upon applications of riveted girder work; the practical design of columns and struts; roof construction; the use of mild steel and iron in marine engineering; and the protection of steel surfaces from corrosion.

The chapter with which we are particularly concerned is that covering the use of mild steel and iron in marine engineering. This takes up the design of iron piers or jetties with their accessories, and goes into considerable detail regarding the sinking of piles and the details of construction of this type of structure. The next part of the chapter covers caissons for entrances to dry-docks or other docks. Details of construction, valves, launching, ballasting, weights and stability are given with profuse illustrations of various types. A number of other uses of mild steel are given attention, but, strange to relate, we do not find any mention of its use in the construction of ships. This forms a very large item in the use of mild steel generally, because merchantmen and warships are almost without exception built of this material in both framing and plating, that is to say, in the items involving the largest proportion of the weight of the ship as a structure.

The illustrations are very numerous and well-designed for the purpose in hand, though the cuts are somewhat crude. An extended index in the rear of the volume adds very much to its use as a book of reference.

The Marine Steam Turbine. By J. W. Sothern. Size, 5½ by 8½ inches. Pages, 163; figures, 77. London, 1906. Whittaker & Company. Price, six shillings, net.

This corrects the item on page 84 of our February number, where the price was erroneously given as sixpence, net.

The Principles of Mechanism. By Herbert A. Garratt. Size, 4¾ by 7¼ inches. Pages, 166; figures, 162. New York, Longmans, Green & Company. Price, $1.10.

The work is divided into two parts:—Kinematics of Machines and Dynamics of Machines. The first part includes all matters connected with the conversion and transmission of motion, without taking into consideration the masses moved or the forces exerted. In this part are five chapters, dealing respectively with mechanisms for directing motion in a straight line; for converting straight line motions into circular motions; for transmitting circular motion from one shaft to another; for transforming circular motions into special forms of reciprocating motions; and differential, intermittent and non-return motions, including some special forms of epicycloidal and hypocycloidal motions.

The second part includes all matters connected with the conversion and transmission of energy, attention being confined to mechanical motions, including some of the simpler aspects of hydrodynamics. This part is divided into four chapters, covering respectively general principles of kinetic energy and momentum; dynamics of the steam engine; dynamics of water motors; and frictional resistance.

The illustrations are all line drawings, most of them being in diagrammatic form for easy apprehension. The book is written without making use of the calculus, but trigonometry and geometry form the basis for a great deal of the text, with accompanying illustrations.

Shipbuilders' Handbook. Arranged by Harrison S. Taft, Ph. B., S. B. Size, 8 by 11 inches. Pages, 323; figures, 3. New York, International Marine Engineering, 1907. Price, in flexible covers, $3.

This consists of abstracts from the rules and regulations of Lloyd's Register, the American Bureau of Shipping, Bureau Veritas, the Great Lakes Register and the British Corporation, together with United States Navy rules for riveting and rules of the Supervising Inspectors of the United States Steamboat Inspection Service. Nearly all of the material has passed through our columns as text during the calendar years 1905 and 1906.

The object of the work was to place in a convenient form for reference the rules of the several societies, in order to make it possible to consult these rules without the necessity of having on hand the several books containing them all. No attempt is made to provide material from which ships can be fully designed, as it is manifestly out of the question to include in such a work tables to the extent required for this purpose. The abstracts are concise, and make use of only the most important points involved under each heading. For purposes of ready comparison, the index has been prepared in the form of a table, so that all the items under consideration are listed, and the index refers directly to the pages on which these items are found under each one of the several headings under which the rules are divided.

The work is printed on right hand pages only, in order to leave the left hand pages free for memoranda as each user may wish to make them. This makes the work even more valuable for reference, as material gathered upon any particular subject may be placed close to the text treatment of that subject, and the whole information is seen at a glance. The intention of the work was to bring the rules and regulations of the different ship classification societies within reach of many who otherwise would not be able to consult them, resulting in furthering the use of these rules as published.

QUERIES AND ANSWERS.

All reasonable questions concerning marine engineering received from and signed by subscribers will be answered by the Editor in this column. All communications must bear the name and address of the writer.

Q. 367.—What is the area required for a float of a stern wheel steamer with given horsepower and revolutions? Give sizes for both radial and feathering floats, and ratio between depth and width. B. S. A.

A.—Very little accurate information is obtainable from those who have it. As a result, the various marine engineering hand books seem to be the only resource for those desiring information. For radial floats, Seaton gives the number of floats as one for each foot in the diameter; the breadth as about one-fourth the length; the thickness as one-eighth the breadth. The area of the float is given by Seaton as $\frac{\text{I. H. P.}}{D} \times C$, where D is the diameter in feet, and C is a coefficient varying between 0.25 for

tugs and other vessels requiring heavy tractive effort, and 0.175 for fast and light steamers.

For feathering wheels, the number of buckets is given by Seaton as $\frac{1}{2}(D + 2)$. The breadth is 0.35 times the length; the thickness is one-twelfth the breadth. The area is given by the same formula as for radial wheels, but the coefficient varies between 0.3 and 0.35. The area might be made in the general case $\frac{\text{I. H. P.}}{3D}$.

The diameter of the wheel is based upon the speed to be attained, the revolutions per minute and an assumed value of the slip. Put in the form of an equation, diameter $= \frac{V}{\pi R (1 - s)}$, where V is expressed in feet per minute, R in feet and s as a fraction. When the speed is given in knots, the numerator becomes 101.3 × knots.

Suppose we take an example where the power to be transmitted is 300 I. H. P., and the speed 12 knots at 30 revolutions per minute. Let us assume 20 percent slip.

The diameter will be $\frac{101.3 \times \text{Kts.}}{\pi R (1 - s)}$.

This becomes $\frac{1216}{\frac{22}{7} \times 30 \times 0.8}$. The result is 16.12, or, say, 16 feet diameter.

For radial floats, we find that there will be sixteen of them. The area of each float will be $\frac{300}{16} \times 0.2$, or 3.75 square feet. We may assume the length of each float as 3 feet 9 inches and the breadth 1 foot. The thickness will figure out at 1½ inches.

For feathering floats, the diameter will be the same. The number of floats will be $\frac{16 + 2}{2}$, or 9. The area per float will be $\frac{300}{3 \times 16}$ or 6.25 square feet. We may take the length of a float as 4 feet 2 inches; the breadth as 18 inches; the thickness as 1½ inches.

It will be noted that the floats as figured out above are for side wheel practice rather than for stern wheel. In the latter case, the floats would for convenience sake be longer and narrower than with the side wheel floats. Just what the ratio between the two would be depends largely upon the conditions to be met, with regard to beam of vessel, the placing of the engines and the character of the stream upon which the vessel is to be used.

Q. 363.—A small water tube boiler with up-flow pipes over the furnace, ¾ inch in diameter, and down-flow pipes, 2½ inches, has steam drum exposed to the heat and flame. Should pipes be made of iron or steel? Should the steam drum be made of iron or steel? Would malleable fittings be suitable for the return bends? The boiler is to carry 250 pounds per square inch. Durability and strength are prime requisites. L. W.

A.—In modern high pressure boiler construction wrought iron pipe or plate is almost an unknown quantity. Seamless drawn steel tubes and steel plate for the drum should be employed. Malleable fittings have been used to some extent in boiler construction of this type, but for such purposes they are inferior to the so-called "homogeneous steel" castings. D.

Personals.

Edwin F. Abel has been transferred from the Bureau of Steam Engineering in the Navy Department at Washington to the Engineering Department in the navy yard at Norfolk, Va., with the title of Chief Draftsman.

Stephenson Taylor has been elected president of the Maine Steamship Company, operating steamers between New York and Portland. The other officers of the company include J. H. McKay, vice-president; D. R. Roome, secretary and treasurer; R. C. Scholtz, traffic manager; and W. T. Berry, superintending engineer. The directors include Messrs. Taylor, McKay and Roome, besides Messrs. N. F., F. F. and George Q. Palmer, C. S. Smith and George E. Weed.

G. B. Hunter, of the firm of Swan, Hunter & Wigham Richardson, shipbuilders, Newcastle-on-Tyne, and Oliver Bury, general manager of the Great Northern Railway Company, have been elected vice-presidents of the Decimal Association.

John Joseph Welch, manager of the shipbuilding department of Cammell, Laird & Co., Birkenhead, has been appointed to the newly-established chair of Naval Architecture at the Armstrong College, Newcastle, in the provision of which Sir William White has taken an active part.

Henry C. Sergeant, of the Ingersoll-Rand Drill Co., New York, died Jan. 30, at the age of 72. He was a prolific inventor, being best known for his work along the line of pneumatic and hydraulic tools and their accessories.

John E. Zimmerman, formerly secretary of the American Pulley Company of Philadelphia, has become a partner in the consulting firm of Dodge & Day, Engineers, Drexel Building, Philadelphia, Pa.

Robert S. Riley has enlarged his interests by taking over the control of the American Ship Windlass Company, of Providence, R. I. Under the new management the company is making great improvements in designs and facilities for manufacturing. Mr. Riley is particularly well fitted to know the demands of modern marine auxiliary machinery, having had a valuable experience as engineer officer in the merchant marine and navy. He is also a director and consulting engineer for the Enterprise Transportation Company.

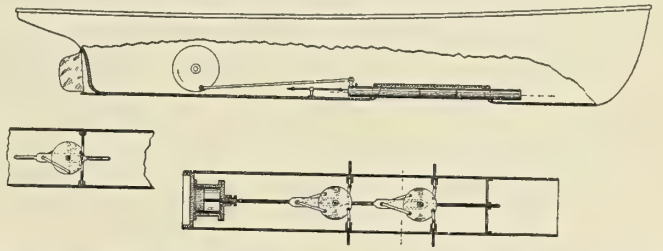
SELECTED MARINE PATENTS.

The publication in this column of a patent specification does not necessarily imply editorial commendation.

American patents compiled by Delbert H. Decker, Esq., patent attorney, Loan & Trust Building, Washington, D. C.

834,324. PROPELLING APPARATUS FOR BOATS. AUSTIN L. RUSSELL, MINNEAPOLIS, MINN.

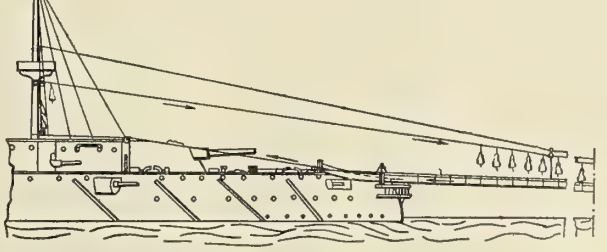
Claim.—3. The combination with a boat-body, of a tube mounted thereon and having its intermediate portion only exposed to the water, propeller-blades mounted to move radially into and out of said tube, a



cylinder and piston-engine mounted in said tube, the piston thereof having an extended rod, crank-disks mounted in said tube arranged in pairs, the members of the pairs one over the other, links connecting said propeller-blades and said extended piston-rod to said crank-disks, and means for reversing the action of said engine at the limits of said tube's reciprocating movements. Three claims.

834,335. APPARATUS FOR COALING SHIPS FROM COLLIERS. CHARLES G. C. C. TAYLOR, BASILDON, ENGLAND.

Claim.—3. In a coaling apparatus, the combination of two vessels, an endless coaling-hawser, rings carried by said hawser, chutes and



blocks carried by said vessels through and over which the said hawser passes, a plurality of coaling-bags each provided with a springhook adapting said bags to be attached to said rings of the coaling-hawser, and means for hauling the hawser.

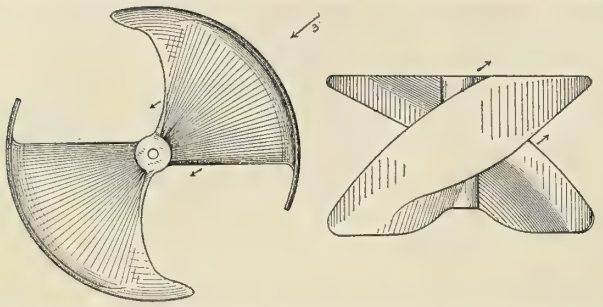
4. In a coaling apparatus the combination of two vessels, an endless hawser, rings carried by said hawser, blocks carried by said vessels to guide said hawser, a towing-hawser, a flexible tube, bands passing around said tube and shackles connected to said bands through which said towing-hawser passes. Seventeen claims.

834,399. APPARATUS FOR CLEANING HULLS OF SHIPS. PETER D. McLELLAN AND JOSEPH F. McKINNON, DORCHESTER, MASS.

Claim.—1. A device of the character described, comprising a plurality of hinged sections, each section provided with a rigid scraper and a flexible brushing surface, a flexible container secured to and covering the back or outer face of all of said sections, and a valve carried by said container. Two claims.

834,624. PROPELLER. ANDREW S. LITTLEJOHN, NEW YORK.

Claim.—2. A propeller comprising a hub and two opposite blades each consisting of a standing wall extending spirally from the hub, a cutwater projecting forward from the blade and a driving-overhang projecting



laterally from the standing wall and cut-water, said overhang acting to prevent lateral movement of the water and to hold the water taken in by the cut-water toward the hub and cause it to be pressed backward out of the wheel in spiral columns, the edge of the reversing-overhang being of less length of radius that the driving overhang. Seven claims.

835,313. SCREW-PROPELLER. GEOFFREY J. O'FLYNN, PELHAM, N. Y.

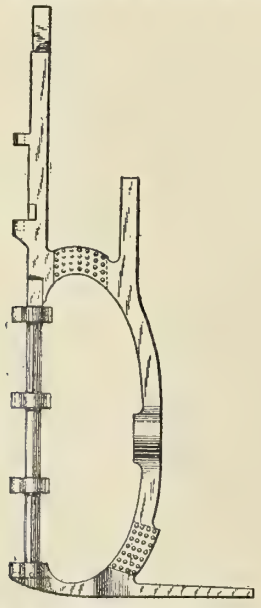
Claim.—A screw-propeller in the form of a spiral having its outer peripheral edge curved throughout its lineal extent at an angle to the

body of the propeller, the convolutions of said spiral extending outwardly in a plane at an obtuse angle to the longitudinal axis thereof and constantly receding from said axis in arithmetical progression approximately the width of the spiral, during each revolution thereof. One claim.

British patents compiled by Edwards & Co., chartered patent agents and engineers, Chancery Lane Station Chambers, London, W. C.

16,137. STERN FRAME. A. A. FOWNES.

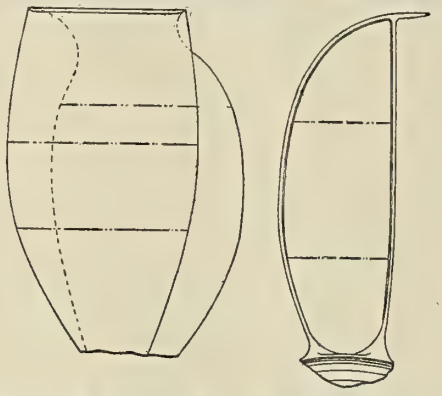
In order that the several parts of a stern frame may be separately renewed, the bottom portion is secured to the bossed portion by a scarfed joint, and the back-post is separate from both the bottom portion and the



bossed portion. The lower half of the back-post is cylindrical and its lower end is shrunk into the frame. The gudgeons are shrunk on to the post and secured by keys. The upper portion of the post is rectangular and is provided with gudgeons forged or cast with it. An extension is secured to the boss-piece by a joint similar to that at the lower portion of the frame.

16,665. SCREW PROPELLER. W. J. GAY AND C. DURDLE.

The blades of screw propellers are formed of an outer portion and a flat



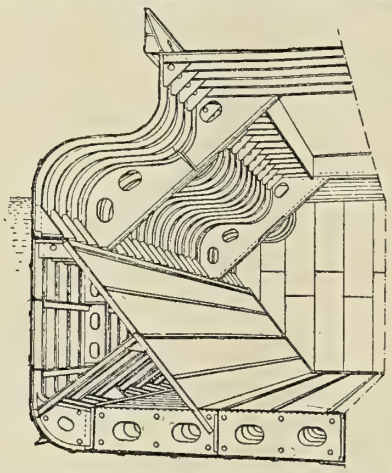
inner portion connected together at their upper ends by a curved portion carried beyond the flat portion to form a lip. The blades are thus in the form of loops.

17,087. INTERNAL-COMBUSTION ENGINE. J. E. THORNYCROFT, R. DONKIN AND V. G. BARFORD.

The cam shaft of a four-cycle reversing engine is driven through bevel, or spur, or chain reversing gearing so that it always revolves in the same direction. Two wheels run loosely on a cam shaft and are driven from the crank-shaft by wheels. Each wheel carries a clutch member, which is shaped so that it will engage with the corresponding part in one angular position only. The last mentioned part of the clutch works on a feather on the shaft. A ratchet clutch with one notch may be used. A small turning engine drives the shaft through worm gearing and a clutch at starting, and when the parts of the clutch stop in a position in which they will not interlock. A hand wheel may be used instead of the turning engine.

17,224. SHIPS' FRAMES AND FRAMING. C. D. DOXFORD.

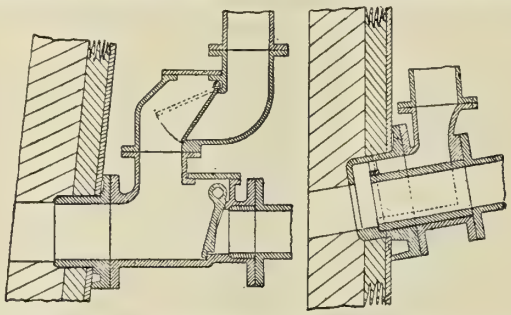
Vessels of the turret type are constructed with inner sloping side walls extending from the double bottom, at a considerable distance from the external plating, to the side of the vessel at a height considerably above the bilge. The walls are supported by brackets or struts or by columns.



The spaces between the plating and the walls are utilized for ballast tanks. The sloping walls permit easy unloading of grain cargoes. The construction described is particularly applicable to the turret vessel, in which the beams and stanchions are removed and gusset-plates and web frames are fitted.

17,693. SHIPS' ESCAPE PORTS. F. J. TREWENT AND W. E. PROCTOR.

The number of holes in the armor of vessels is reduced by forming a junction between the scupper pipe and the ash-ejector pipe, so that both discharge through one opening. In one example, the scupper pipe and the ash-ejector pipe are united to a junction-box, and provided with non-return



valves. The valve boxes are fitted with inspection covers. In another example, the valves are omitted, the box being a simple junction pipe. In a third example, the ash-ejector pipe projects into the junction box. The projecting portion may be either eccentric or concentric with the junction box, and formed separate from the ejector pipe, and resting on the seating. A valve may be fitted to the scupper pipe. The invention is applicable to steamships generally.